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The effect of macroeconomic variables on food security in Guatemala

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by

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CHAPTER 1. INTRODUCTION

Guatemala is a less developed country in Central America which suffers from periodic severe shortfalls in the ability to provide the minimum levels of foodstuffs to its people (food insecurity), where minimum is defined by the Food and Agriculture Organization (FAO) as 2195 calories per capita per day for Guatemala. During the historical period of this study (1960-1983), the average level of calories provided to the people of Guatemala has been 2006, or about 92 percent of the FAO minimum requirement. There are several reasons for this inability to provide the minimum amount of food, but they can be broken down into two major areas: production of foodstuffs, and macroeconomic variables. First, the foodstuff production sector of Guatemala will be examined, and then the macroeconomic sector will be examined, in the context of food security.

Production of foodstuffs in Guatemala, although increasing, as measured by the cereal production index, is subject to a great deal of variability over time, which decreases the country's ability to provide a consistent level of food to its people. The variability in production is often due to the weather patterns of the region, and also due to the low levels of inputs such as fertilizer and quality seed. The variability in production of food shows up in the variation in the average yield over time, which tends to be high and also in large changes in area harvested. As will be seen in the body of the paper, the historical variability in the production of corn, the major food crop making up about 65 percent of food production, is significant, and has important implications for the probability that Guatemala will be food secure. The variability in production of the other so called basic grains: rice, sorghum, and beans, is also significant, although these crops make up a much smaller share of production and consumption.

Macroeconomic variables also play a significant role in Guatemala's abiliy to provide food for its people. The level of income and trade indicate how much food Guatemala can purchase both on the world market, and on the domestic market. The most important macroeconomic variable for Guatemala is income, measured as per capita gross domestic product (GDP). The low levels of per capita income decreases the purchasing power of the people, and thus, do no allow for the purchases of the necessary amount of food. Low levels of income have a second effect. The low purchasing power does not create strong effective demand for the food products produced in the country, and thus, there is little incentive for the food producers to adopt high quality seeds, or to use inputs such as fertilizer or irrigation.

Trade, as a generator of foreign exchange, also has a significant effect on the level of food per capita in Guatemala. Guatemala places emphasis on export crops, especially coffee. Recently, coffee made up about one-third of the total export value of Guatemala, and this share is consistent over the historical period of this study. Normally, a dependence on an export crop for income is not bad, however, coffee prices are subject to large changes over time. A change in coffee (and other export crops such as cotton) prices has two effects, depending on the direction of movement. If the price is high, land area and other production resources will be allocated away from food crops to the export crop. This results in a greater amount of foreign exchange, but a weaker food production base. If the price of coffee were to fall after a long period of high coffee price, Guatemala will find itself (and has found itself) unable to provide an adequate amount of food. If the price of coffee is low, Guatemala will not have a lot of foreign exchange available to trade for food on the world market, and thus, will not be able to cover its own shortfalls in production.

Population is another important macroeconomic variable for Guatemala. The high population growth rate, currently about three percent per year, places tremendous pressure on the food supply; both the currently available amount of food, and also the fututre production potential of the land. As noted previously, food production is increasing at about 3 percent per year, but population growth is using up this food increase. The percentage of population that is economically active is also an important macroeconmic variable relating to food security. Currently, only about 30 percent of the people in Guatemala are defined as economically active. This results in low levels of GDP, and low levels of effective demand for domestic food products.

There are many difficulties in the Guatemalan economy, which make it difficult to provide adequate amounts of food. The combination of low income levels, trade imbalance, and variability in the production of basic grains combine to hold the probability of food security to low levels. Although it is clear that these variables have an effect on food security, there has not been a lot of research done to quantify the effect of these variables on food security. Therefore, this study will attempt to quantify the effects of these variables, which will then be useful in suggesting policy options to alleviate food insecurity in Guatemala.

Review of Literature

Food security, with respect to both its causes and solutions, has been and will continue to be an important research topic. Most studies of food security do not treat the economy as a whole, but rather one sector, usually the food production sector. This relative weight toward the food production sector indicates the importance of food production food security, and therefore, most of the studies in this Literature Review deal with food production. Also, the effects of food insecurity on the people of Guatemala must be understood so that appropriate emphasis can be placed on the goal of food security. The literature that is reviewed in the first part of the review of literature will deal with the causes of food insecurity, and the second part of the review of literature will deal with the effects of food insecurity.

There are two types of studies that deal with the analysis of the causes of food insecurity. The first of these is an analysis of variance technique to analyze the variation in consumption. Examples of this type are studies by Greene and Kirkpatrick, and by Valdés and Konandreas.

In a study of less developed countries, Greene and Kirkpatrick (1982) examine an accounting equation of the type

$$C = Q + F - S$$

where

C = consumption

F = imports

S = exports

Q = production

for which the variance of the components is

$$\sigma_{CC} = \sigma_{QQ} + \sigma_{FF} + \sigma_{SS} + 2\sigma_{QF} - 2\sigma_{QS} - 2\sigma_{FS}$$

to measure the source of food insecurity, where food insecurity is defined as variation in consumption over time. With the variance in consumption defined as above, the authors used regression analysis to test the explanatory power of the variance of the independent variables on the variation in consumption. They find that the variation in production has the largest effect on the variation in consumption in the regression equation. This might be expected, since a relatively poor country with income constraints would depend on its own production for the majority of its consumption, and use food imports to a lesser degree to meet food needs.

Valdés and Konandreas (1981) examine the variability of food supply in a study of less developed countries during the period 1961 to 1976 as a function of the food import bill. The equation for food import costs

$$V = MP$$

where

V = value of food imports

M = imports of food in quantity terms

P = price of food

This equation can be expanded to express the relative share of variation caused by each of the components, as well as their interaction. This equation

$$R_m + R_p + R_{mp} = \frac{\overline{P}^2 \cdot Var(M) + \overline{M}^2 \cdot Var(P) + 2\,\overline{P} \cdot \overline{M} \cdot Cov(P,M)}{\overline{P}^2 + Var(M) + \overline{M}^2 \cdot Var(P)}$$

where

R_m = variation due to quantity

R_p = variation due to price

R_{mp} = variation due to interaction

enables the authors to determine the sources of variation. In this study, the authors focus on the food import bill as the source of food insecurity, because they feel that production is already relatively stable, and imports will then be the source of instability in the consumption of food. Valdés and Konandreas find that the variability in the quantity of imports is the major cause of import bill variability; however, the authors note that the study was done over a period of relatively stable prices, and thus, may be biased toward that result. Results specific to Guatemala indicate more of the variability is due to quantity, although price variance is also important. Although this is a valid technique for analysis, it would be more significant if imports where a larger share of total consumption. Additionally, the variance in the import bill is not necessarily bad. High variance in the import bill may indicate that Guatemala is purchasing foodstuffs to cover domestic shortfalls. This appears to be the case in several years of the historical period of this study.

The second type of analysis of the causes of food security is a type of study that uses statistical tools such as the coefficient of variation and the probability of shortfall. Both of these types of studies are common, and only one of each will be presented here.

The coefficient of variation measure is applied by Valdés and Konandreas (1981) in their study of food insecurity of less developed countries during the period 1961 to 1976. A linear trend of production is developed by using ordinary least squares regression techniques with time as the independent variable. The deviation around this line, in percentage terms, is the coefficient of variation.

The authors of this study find that higher levels of food insecurity are associated with higher coefficients of variation, where food insecurity is measured as a variation in consumption.

In a study of less developed countries, Yumiseva (1983) develops the probability of shortfall measure, and tests its usefulness in describing food insecurity. This measure uses the deviations around a linear time trend to calculate the probability of a five percent shortfall. Using the formula

$$Pr(C < (1\text{-}X)C) = Z[(-\ \hat{C}\ \hat{\alpha})/S]$$

where

Pr = probability

Z = normal distribution

$\hat{C}$ = trend line

X = percent shortfall

S = standard deviation

$\hat{\alpha}$ = intercept of trend.

Yumiseva finds that higher probabilities of five percent shortfall are positively related to other measures of food insecurity, such as the coefficient of variation.

In a study of less developed countries, Bachman and Paulino (1979) tested the relationship between factors such as population growth and trends in food production on the probability of food security. They found that countries that have more rapidly increasing incomes are more likely to be food self-sufficient, and countries that have lower than average growth in population are also more likely to be food self-sufficient.

Roumasset (1982) suggests an indicator of food risk. This measure

$$RFI = Pr(VS > EE)$$

Where

RFI = risk of food insecurity

VS = value of consumption shortfall

EE = exchange entitlement

Pr = probability distribution

has not been tested in the literature; however, it has economic appeal, since it specifies more accurately the cause of food risk, namely production and income variables, unlike the previously mentioned studies which use only time as the independent variable. Also, it can be used to improve upon an indicator similar to the probability of shortfall measure, such as that developed by Yumiseva (1983).

The second type of food security studies examine the effects of food insecurity, and also suggest other variables as indicators of food security.

Anderson and Scandizzo (1984) quantify the effects of food insecurity, rather than the causes of food insecurity, using a cross-sectional data set on developing countries. They test for variables that are related to the effect of food insecurity, where food insecurity is defined as the probability of starvation. The general relationship is expressed as: food risk depends on normal food availability, distributional risk, and production risk. Several important results come from this study. First, life shortfall and infant mortality, the measures of probability of starvation, increase with the variation of cereal production, and the percentage of the population that is in poverty. GNP has a negative sign, but is not significant. Income inequality as measured by the Gini coefficient has a statistically significant negative sign in the model. Thus, variation if food production, as well as variation in purchasing power, have negative effects on the well-being of the people.

Using cross-sectional data on plantations in Guatemala to examine the effects of seasonal variation of food availability on health related variables, Valverde (1985) found that periods which have less food availability, such as pre-harvest and the rainy season, are related to poor health, an effect of food insecurity.

Justification of the Study

This analysis, a quantification of factors that effect food security, is necessary for several reasons. First, independent variables included such as income, food production, and trade are important to the people of Guatemala. These variables have been and will continue to be important to the level of food risk in Guatemala. Second, measures such as the coefficient of variation do not have a lot of prediction power, and generally explain only a small proportion of the variation in consumption and production, and also have less economic appeal. Third, measures of changes in food security are needed to evaluate the impacts of proposed policy variables such as debt financing, cereal import facilities, trade flows, and export stabilization facilities.

Objective of the Study

Given a need for further development of risk of food security indicators that examine the probability of food security using more relevant independent variables than time, and the suggestions of Roumasset (1982) and of Anderson and Scandizzo (1984) in their research about possible forms of this equation, the objective of this research will be to better explain food security risk using a form of the Roumasset indicator.

CHAPTER 2. MODEL SPECIFICATION

Theoretical Model

The theoretical model used in this analysis is a qualitative choice probability model (logit) where the dependent variable is defined as

1 if food minimums are met

0 if food minimums are not met

where the dependent variable is based upon 95 percent of FAO consumption target levels, a level which is similar to the probability of shortfall measures used by Yumiseva (1983). The logit model was chosen over more conventional linear models for several reasons. First, the logit model allows the calculation of a probability distribution directly, which is of interest in evaluating such policy options such as food stock programs. Second, logit allows setting the consumption target at levels below 100 percent of FAO minimum requirements. This is useful because people can presumably survive minor shortfalls in consumption, and thus, will not react to them. Third, from a practical standpoint, detailed data on consumption will not be available as it is for this study. Development workers in the field can use indicators of health, such as those developed by Anderson and Scandizzo (1984) as the dependent variable. For example, the dependent variable could be defined as 1 if the person is reasonably healthy (assumed to be due to adequate food) and 0 if the person is not healthy. Then a model can be developed with food production and macroeconomic data as independent variables. The logit model can be described as follows. The model is based upon the logistic cumulative density function, which restricts the predicted probabilities to the interval (0,1), with the tails of the probability distribution coming close to the (0,1) points. The form of the function is such that the largest changes in probability occur near the .5 level of probability. For this reason, logit was chosen over the other important qualitative choice model, Probit, since it is reasonable to assume that the probability will change only slightly for the independent variables when they are at their extreme values, and change more when the independent variables are near the indecision point, or the point near the .5 level of probability. The dependent variable, in this study, the probability of food security, predicted by the independent variables is defined as

$$Pi = \frac{1}{[1 + e^{-(\alpha + xB)}]}$$

where

B = matrix of calculated coefficients

x = column vector of independent variables

e = 2.71828

α = intercept of trend line

Because of the specification of the independent variable in the logit model, maximum likelihood methodology is employed by the statistical program to solve the equation specified later in the study. With the estimated coefficients generated by the logit model, it will be possible to quantify and evaluate how the independent variables effect food security, and the magnitude of these effects.

Variable definitions

The definitions of the independent variables and explanation for inclusion in this analysis are as follows.

GDP per capita—The per capita GDP is an important variable in food security measurement. As pointed out by Anderson and Sandizzo (1984), GDP can have some effect on the ability to purchase food and thus on life expectancy. Low GDP levels will also prohibit the purchase of food on world markets to cover domestic shortfall, as well as failing to providing strong market incentives to domestic food producers. Also, higher levels of per capita GDP will allow more purchases in country, and less exports of food grains in shortfall periods. This variable has an expected positive sign.

Debt to exports—The debt to exports measure looks at the total level of outstanding debt with respect to the total value of exports. This indicator will measure the ability to purchase food on the world market-presumably there is pressure on Guatemala to use some of its export earnings to pay off debt. Also, a low value of exports allows less food to be purchased absolutely without the acquisition of more debt. The expected sign is negative.

Value of production/exports—This variable will measure the relative food purchasing power of Guatemala. As the value of the production shortfall, measured as

$$VSF = (\text{corn price} * (\text{consumption} - 2085))$$

gets large relative to the value of exports-the money that is readily available to purchase food, the probability that Guatemala will not be able to meet its food needs is lowered, or the probability of food insecurity increases. The expected sign of this variable is negative.

Population growth—This variable will be measured by using the exponential growth rate from year to year. The increases in population put pressure on several parts of the economy. First, the population growth quickly uses up available production of food. Second, high population growth rates put pressure on the future supply of food. Third, per capita GDP growth rates are decreased by large population increases. The expected sign of this variable is negative.

Food production per capita—The food production per capita variable indicates that if food production is increasing, there will be less risk of a shortfall in consumption. The expected sign is positive.

Current account balance—The current account balance, the balance of merchandise imports and exports, variable is a short term measure of the amount of funds available to purchase food on the world market. It is also included to measure debt trends. Also, the current account variable will measure the emphasis that may be placed on export crops such as cotton. If debt continues to increase, a policy decision may be made to produce more cotton, and leave less land for the production of foodstuffs. The expected sign of this variable is positive.

Empirical Model

Four preliminary specifications of this model were tested in this analysis. Each was designed to capture the variables income, debt, nd foodstuff production, which are important to food security in Guatemala. The four models where:

1) YN = VSFEV, MP, PCGDPEX, CALGDPD

2) YN = VSFEV, MP, PCGDPEX

3) YN = MP, PCGDPEX, CALGDPD

4) YN = VSFEV, MP, PCGDPEX, DEBTEX

where

VSFEV	= value of shortfall divided by export value
MP	= per capital corn production
PCGDPEX	= real per capita income less exports
CALGDPD	= deflated current account beginning balance
DEBTEX	= debt to export ratio
YN	= (0,1) dependent variable.

Model two was rejected because of the low significance level of MP and PCGDPEX, and more importantly, model two was rejected because it predicted zero probability in 1972, when the actual value was one. Model three was rejected because the overall fit of the model, as measured by the log-likelihood ratio and plot of predicted and actual values over

the historical period was not acceptable. Model four was rejected because the addition of DEBTEX did not add significantly to the overall prediction power of the model. Model one was selected because the fit was improved significantly over model three with the addition of VSFEV to the model. Also, with the addition of VSFEV, the model more closely resembles the Roomasset indicator. The empirical results for model one are as follows.
(t values in parentheses)

YN = -67.818VSFEV+.019648MP+.017573PCGDPEX+.0081995CALGDPD-41.124

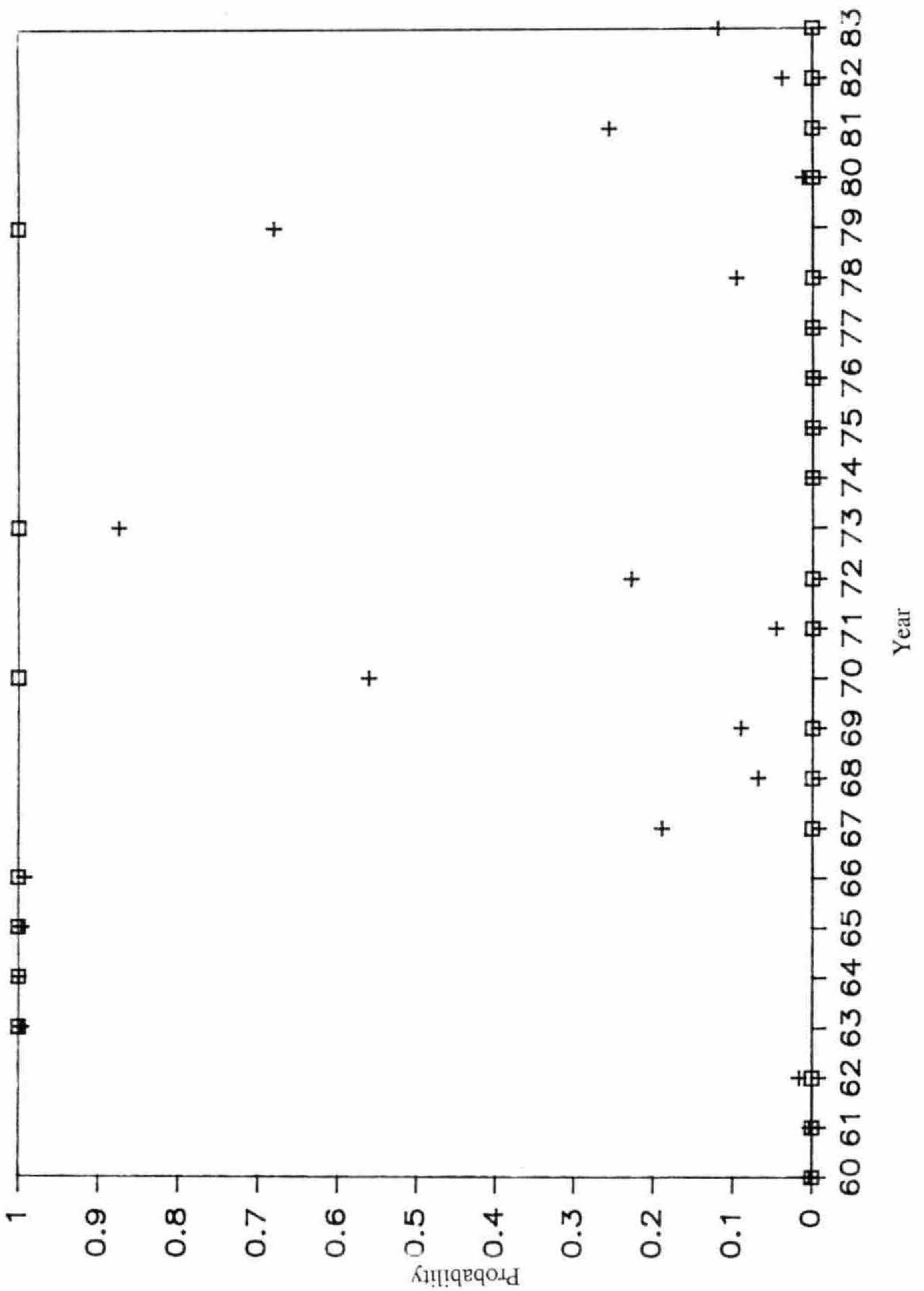
(-.653) (1.20) (1.19) (1.04) (-1.28)

$R^2 = .9121$.

Log-Likelihood ratio = 20.6 (significant at 5% level) .

In the analysis, the food shortfall is assumed to be made up with corn, because this is the most common food for the Guatemalan people, and it should be more readily available for purchase. The U.S. gulf port price of corn is used to calculate the value of the shortfall (VSF) because it is a good indicator of the world price. In this analysis, transportation costs do not enter the value of shortfall calculation. The production variable (MP) is the per capita production of corn in Guatemala, which serves as a proxy for food production as a whole, because data on per capita availability of all foodstuffs show production of the other foodstuffs moves closely with the corn production variable. Also, corn production was used because it makes up from sixty to seventy percent of the per capita food production. It may seem trivial to include such an important variable in the probability of shortfall equation; however, even with the emphasis in this study put on other factors such as debt and income, corn production is still the most important factor in providing food to the people of Guatemala. Per capita GDP less exports in 1980 prices (PCGDPEX) was included in the equation because of the importance of income and purchasing power on both the ability to

Fig. 1. Historical. Plot of actual (□) and predicted (+) probabilities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0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Year
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83

create effective demand in Guatemala, and as an indicator of ability to import food when needed to cover domestic shortfalls in consumption. The current account variable (CALGDPD) is a measure of debt trends, and of available cash to purchase food. The negative value of the current account indicates that the country is purchasing more than it is receiving for its goods in value terms. The value used for CALGDPD in this equation is the ending balance for the previous year deflated by the GDP deflator. It is this value that the Guatemala must somehow make up to avoid further debt problems, and must consider when it purchases food. Unlike the value of shortfall variable (VSFEV) which is a flow across the year, the current account balance variable (CALGDPD) is a beginning debt on the country that policymakers consider when developing their programs.

The results of the historical analysis are that VSFEV has the expected negative sign, but is not significant at the ten percent level. There may be some concern over the lower significance level of VSFEV. However, excluding VSFEV tends to decrease the accuracy of the model, as measured by R^2 and the plot of predicted and actual probabilities, both of which show the importance of VSFEV. The production variable (MP) is more significant, indicating its positive influence in increasing the probability of food security. PCGDPEX also has the expected positive sign. CALGDPD is positive as expected also, although its significance level is slightly low. The plot of the expected values and the predicted values over the historical period show several important results (Fig. 1). First, the actual and predicted values are within fifteen percent of each other in about eighty percent of the years. This could be thought of as correct in eighty percent of the years. Second, the predicted probability is always on the correct side. That is, if the model prediction was for fifty percent or greater, the actual probability was one, and if the predicted probability was less than fifty percent, the actual value was a zero probability. For forecasting purposes, which is the ultimate use of a model such as this, the ability of the model to get on the right side of the probability is important. However, predicted probabilities that are near the fifty percent level will have to be considered carefully.

One thing that the model cannot do is give an accurate measure of the extent of the shortfall, although it can indicate relative magnitude. For example, in 1970, the model predicts 56 percent, a level close to the middle of the probability distribution, and the actual calorie consumption for 1970 was three calories above the FAO recommended level. Similarly, in the period 1974 to 1978 the model predicted zero probability of food security. In these years, low production resulted in severe calorie shortfall, and finally, in the mid 1960s, the model indicated around 97 percent probability of food security. In these years, the calorie consumption was well above the FAO recommendation. An additional strength of the model is its ability to predict in the late 1970s and early 1980s, when debt has been increasing rapidly, as measured by the CALGDPD variable. The model does well in predicting these economic events that will continue to plague these countries.

Model Validation

In this section, several different possible scenarios will be examined to test the empirical model, and also to indicate the magnitude of change in the independent variables needed to increase the probability of food security to acceptable levels, where acceptable is defined to be 50 percent probability or greater. Changes in corn production (MP), real current account balance (CALGDPD), value of shortfall (VSFEV), and real GDP less exports (PCGDPEX) were shown by the empirical model to have a significant effect on food security. The effects varied in magnitude, due to both the size and significance of the calculated parameters, and their cross effects. For all of the scenarios, population growth was held constant at 2.75 percent per year. This maybe slightly high in the later part of the projection period, but is a good overall number to use. When a variable is constant it is assumed to stay at 1983 levels over the projection time period (1984-2000) (see Appendix D).

Baseline

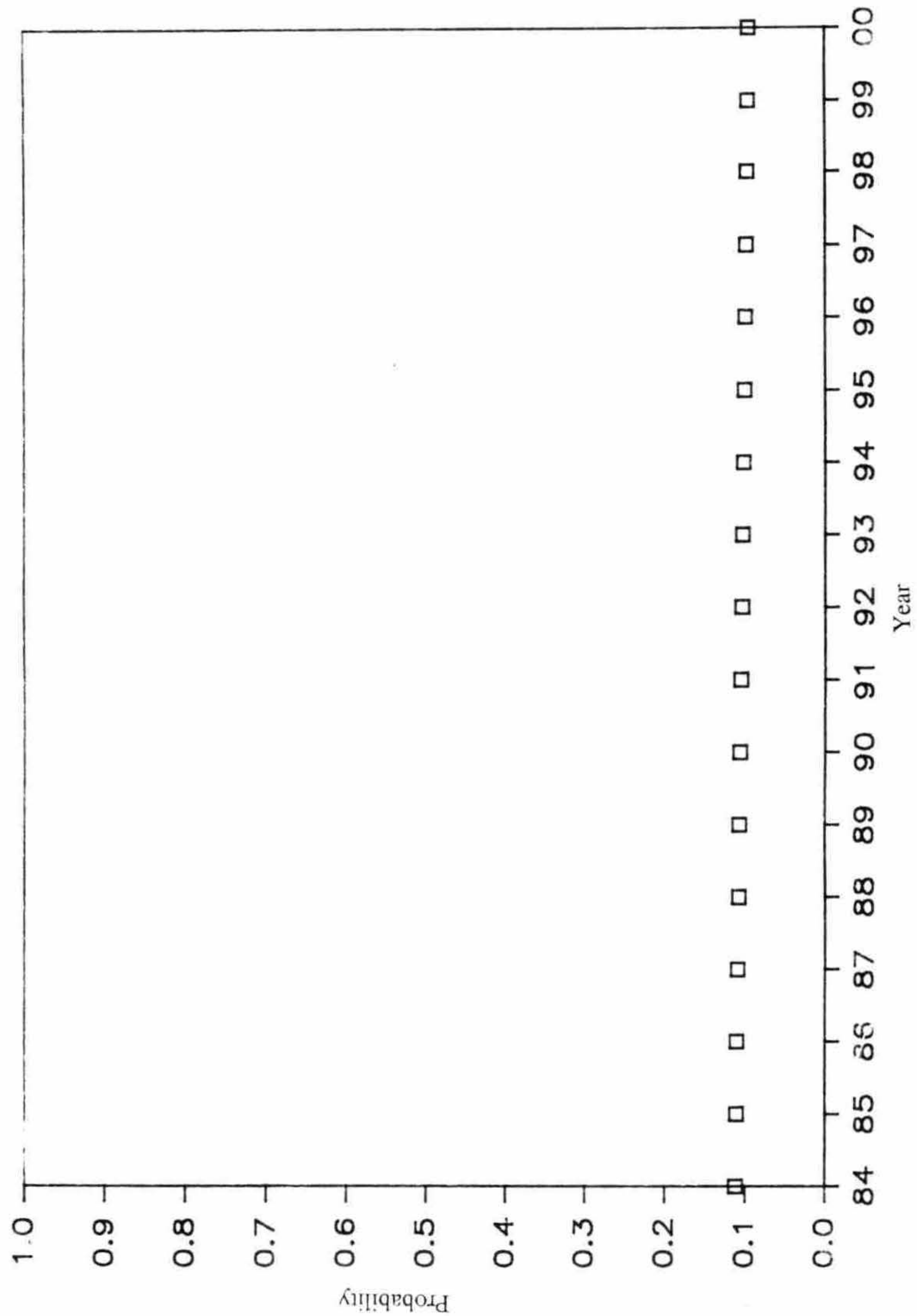
In the baseline scenario (Fig. 2), the independent variables are held at their 1983 levels. In this scenario, very little change takes place. The probability of food security falls from about eleven percent in 1984 to around nine percent in the year 2000. This scenario shows that if current levels (1983) continue, there is only a slight probability for an adequate supply of food. The fall in probability of food security comes from the effect of increasing population (POP) over time on the negatively signed value of shortfall (VSFEV) coefficient. In this baseline, corn production and per capita income are increasing, but at the same rate as the population. Therefore, per capita levels for these variables are the same over time.

Changes in the real current account balance

The value of the current account (CALGDPD) effects food security probability by its effects on trade decisions. With a higher negative value of the current account, there is less incentive for Guatemala to trade for food on the world market to make up food shortfalls. Also, land use for food may be altered in favor of income generating non-food exports such as coffee and cotton. The current account scenario increases the current account value by five and ten percent per year, and also decreases the current account value by five percent per year (Figs. 3, 4, and 5).

The five percent increase per year in the current account has a fairly significant impact on the probability of food security, but it is very important to note that the level does not go over fifty percent, thus, a five percent increase per year does not really help increase the probability of food security significantly. A ten percent increase in the real balance of the current account, however, increases the probability of food security more rapidly, and

Fig. 2. Baseline. Plot of predicted probability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0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Year
84
85
86
87
88
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90
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94
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99
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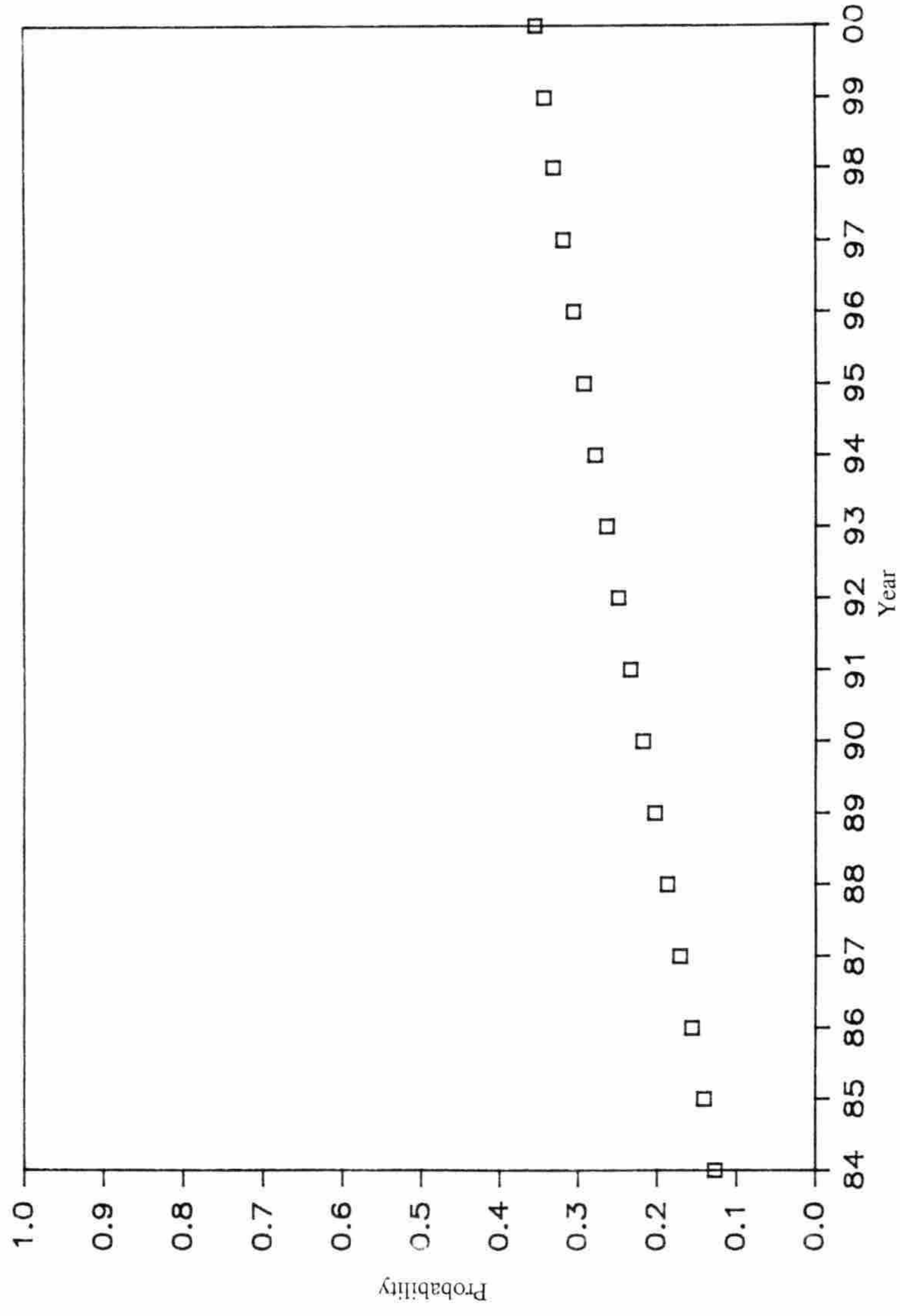
Fig. 3. 5% current account increase. Plot of predicted probability


Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Year
84
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92
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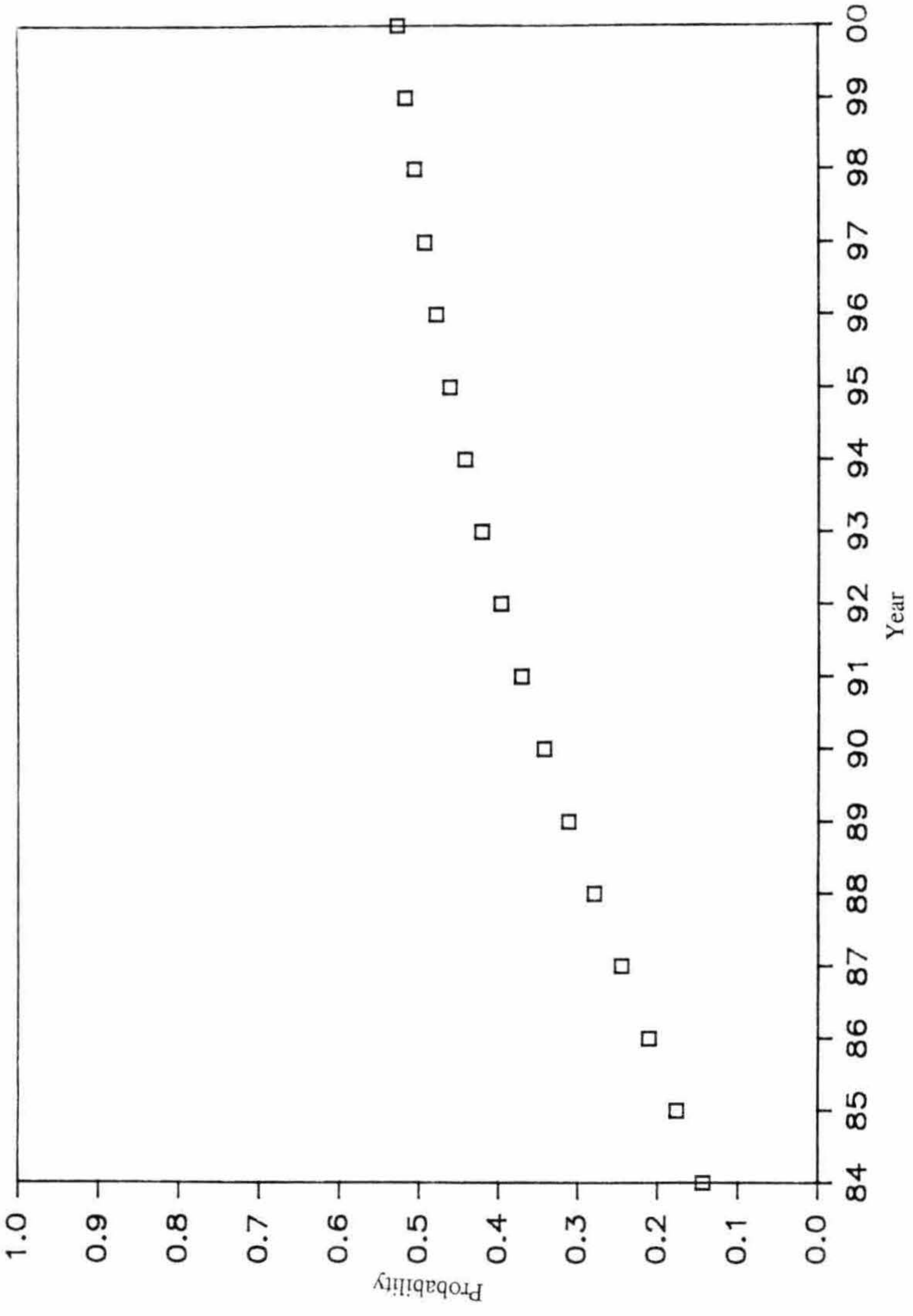
99
00

Fig. 4. 10% current account increase. Plot of predicted probability


Probability
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0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Year
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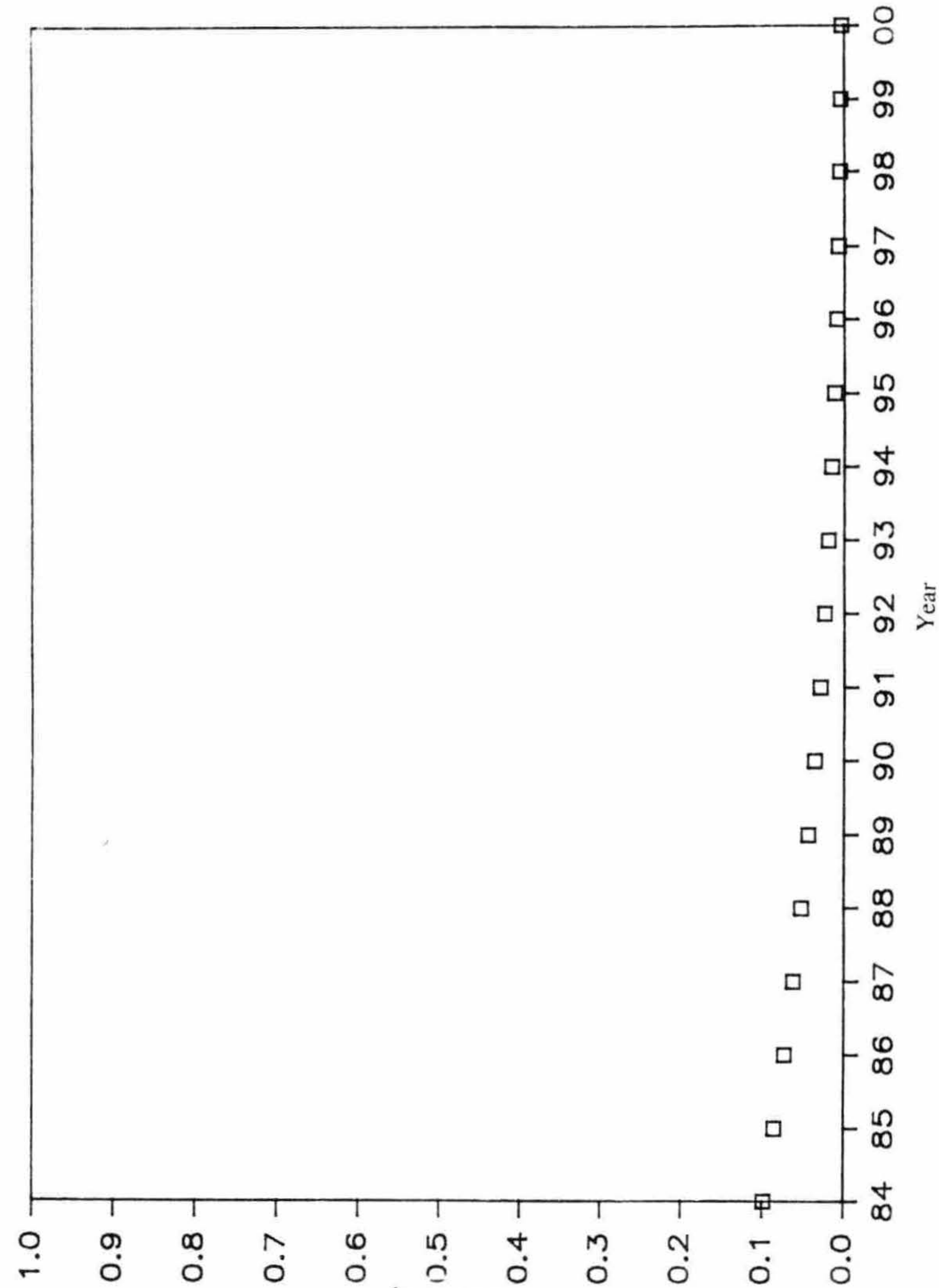
Fig. 5. 5% current account decrease. Plot of predicted probability



Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
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Year
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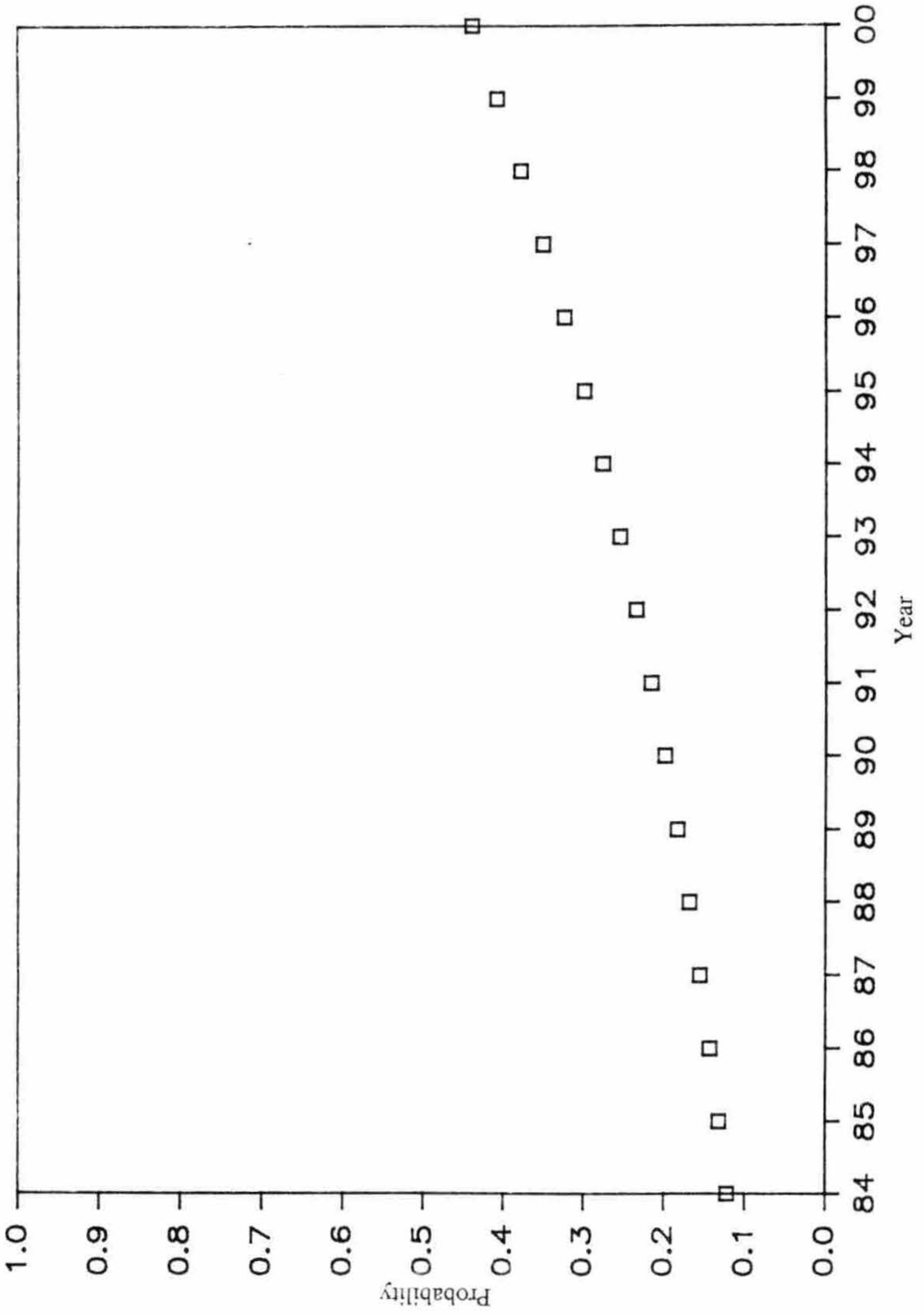
probability levels of over fifty percent probability are reached in 1997. Again, it must be noted that the level is just over fifty percent, and in later years, the probability does not increase significantly. A five percent decrease drops the probability of food security quickly to near zero, from about eleven percent over the time period 1984 to 2000.

The current account can have an effect on food insecurity, but its magnitude is not significant enough to warrant full attention on it alone as a cure for food insecurity in the current account scenario, it is assumed that land can be changed from the production of export crops to food crops readily. To the degree that this cannot be done, the results are dampened.

Changes in corn production

In these case studies, three different rates of per capita corn production (MP) growth per year are examined: a growth of .25 percent, a growth of .5 percent and growth of .75 percent per year (Figs. 6, 7, and 8). The increase in corn production also effects the value of shortfall variable (VSFEV), decreasing it in this case. Thus, MP has a twofold effect and, therefore, increases the probability of food security rapidly over time. The increase of .25 percent has a significant increase in the probability of food security, slightly higher than the effect of a ten percent increase of the current account, but comes nearer to the fifty percent level by the year 2000. However, it does not go over the critical fifty percent level. Food security probability is increased more rapidly with the .5 percent increase in MP. The fifty percent level is reached in 1992 and increases steadily throughout the period of the projection. With a per capita increase in food production of .75 percent, food security levels are achieved by 1990, and hold at high levels (above 85 percent) from 1996 to 2000. These scenarios show the importance of growth in the food production sector on food security. Also, it must be noted that technology is applied to the food production sector as a whole,

Fig. 6. Corn production growth of .25%. Plot of predicted probability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0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Year
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Fig. 7. Corn production growth of .50%. Plot of predicted probability

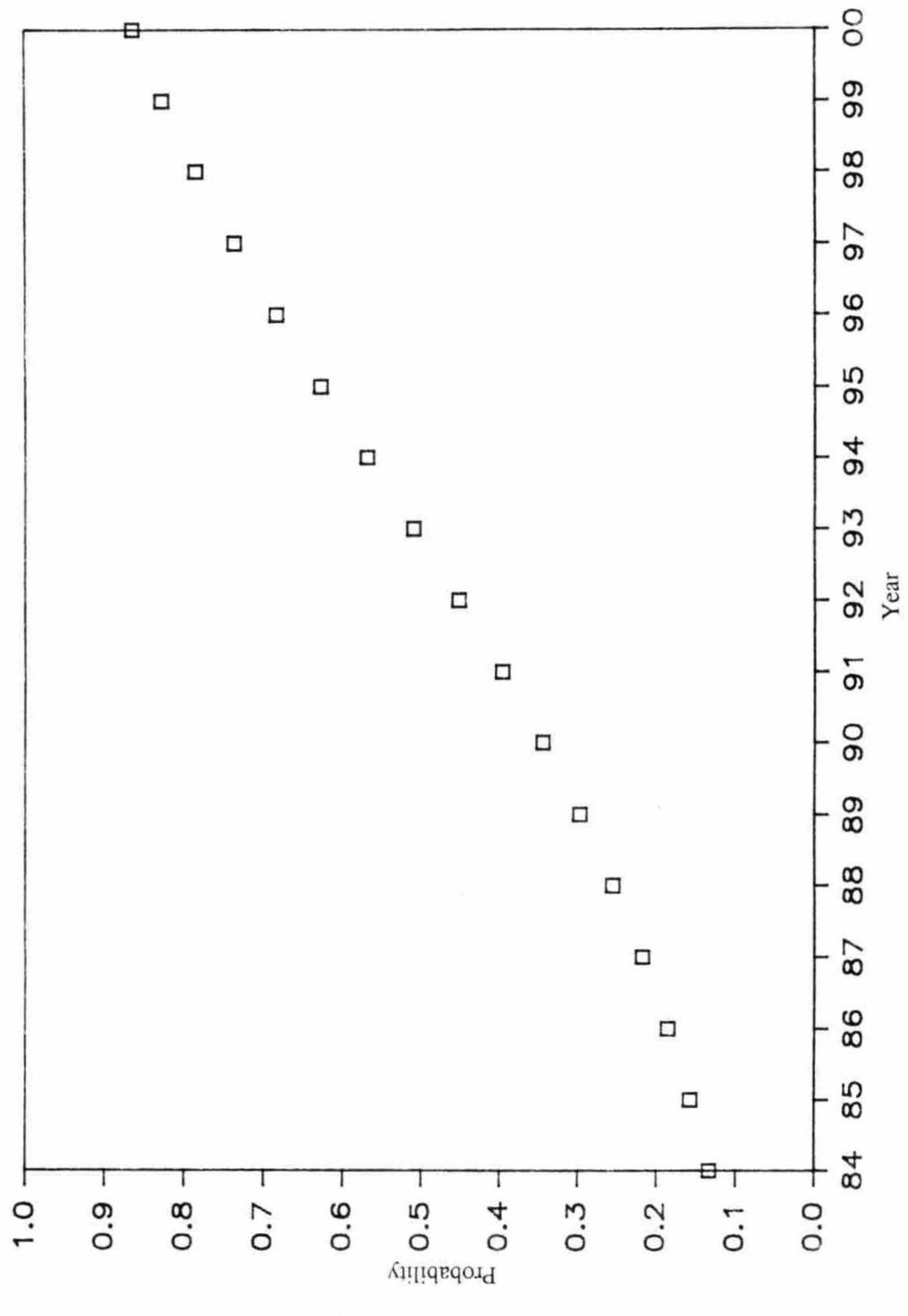
Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Year
84
85
86
87
88
89
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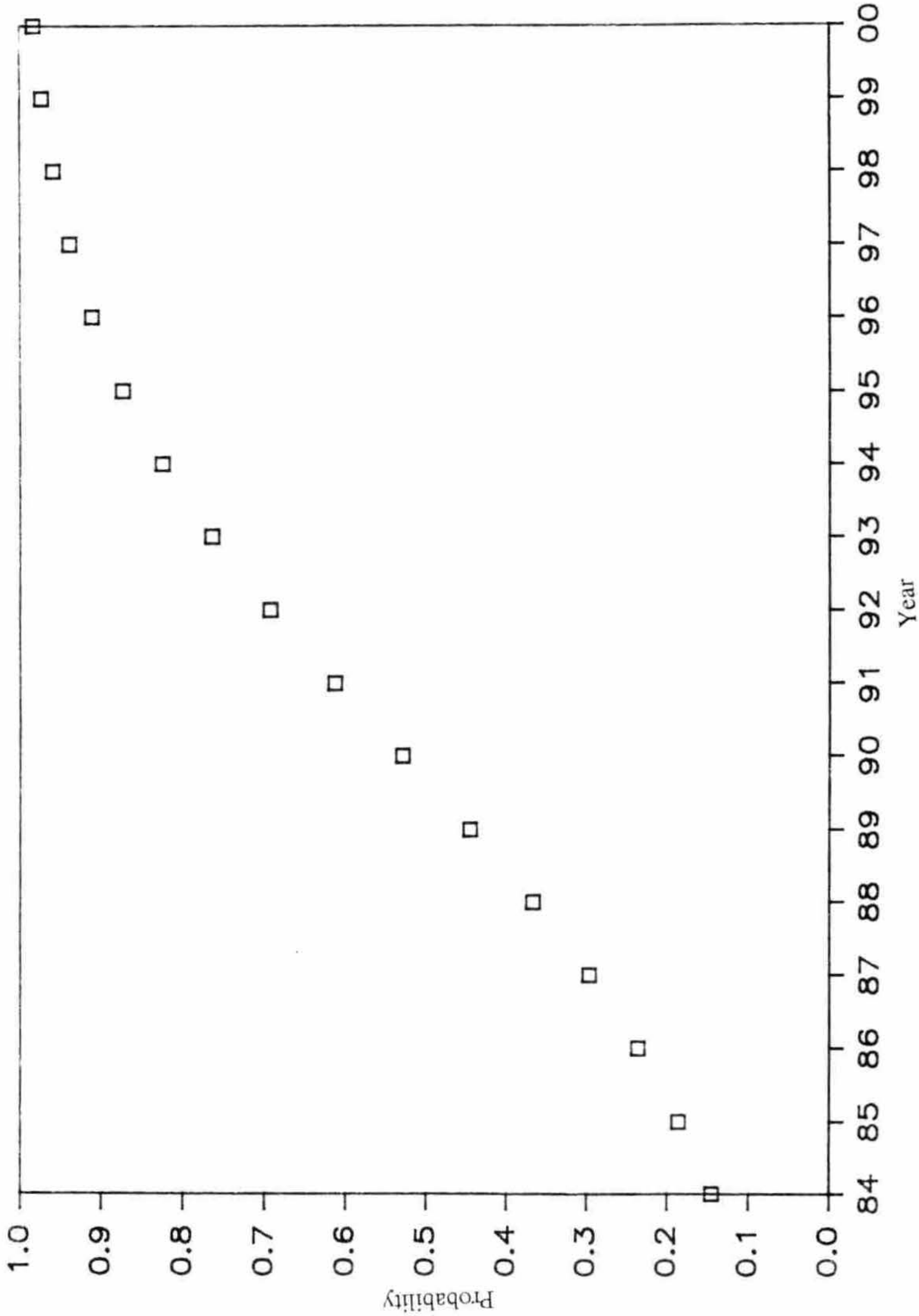
Fig. 8. Corn production growth of .75%. Plot of predicted probability


Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
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0.0
Year
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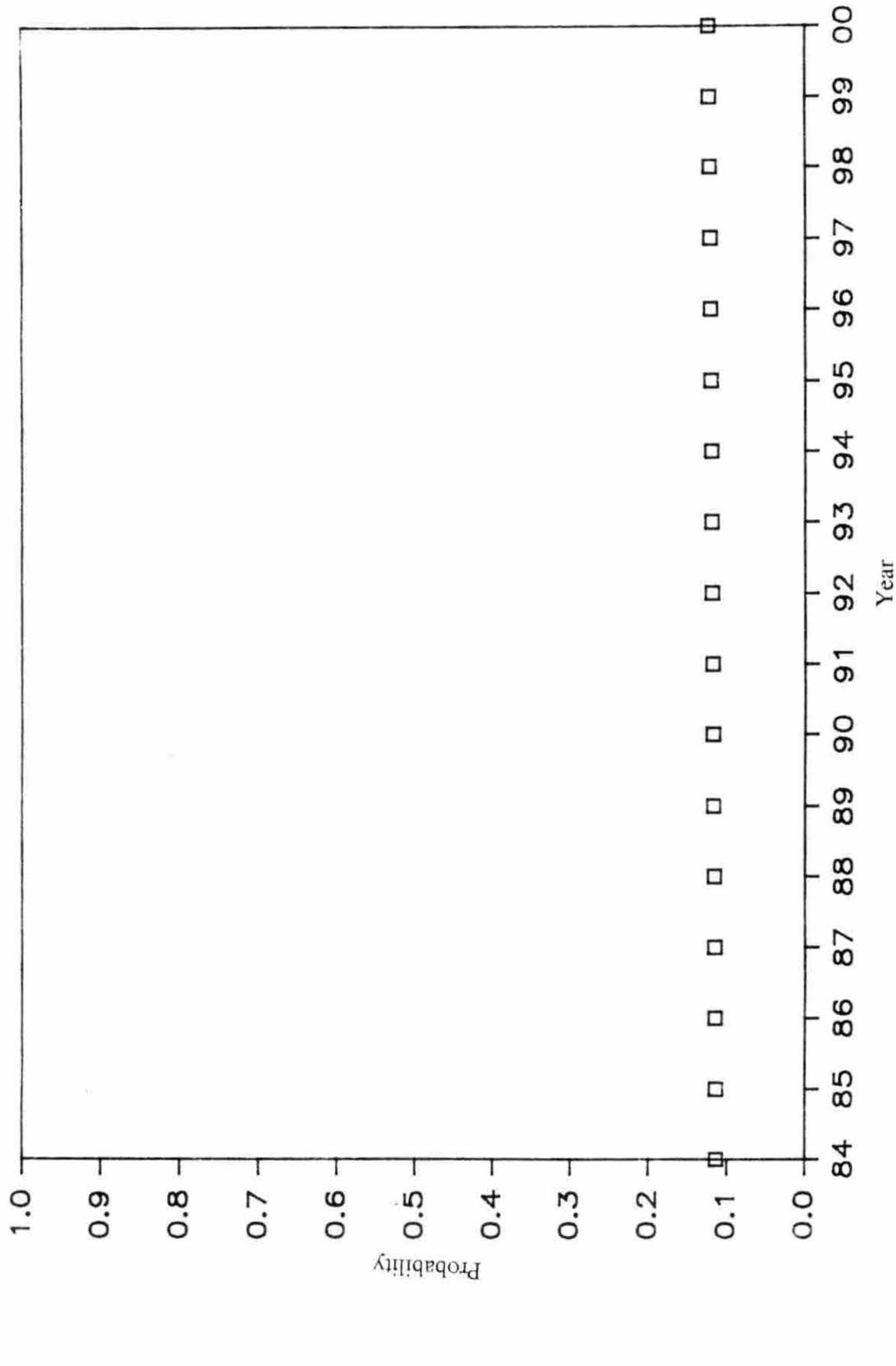
Fig. 9. 5% export value increase. Plot of predicted probability



Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
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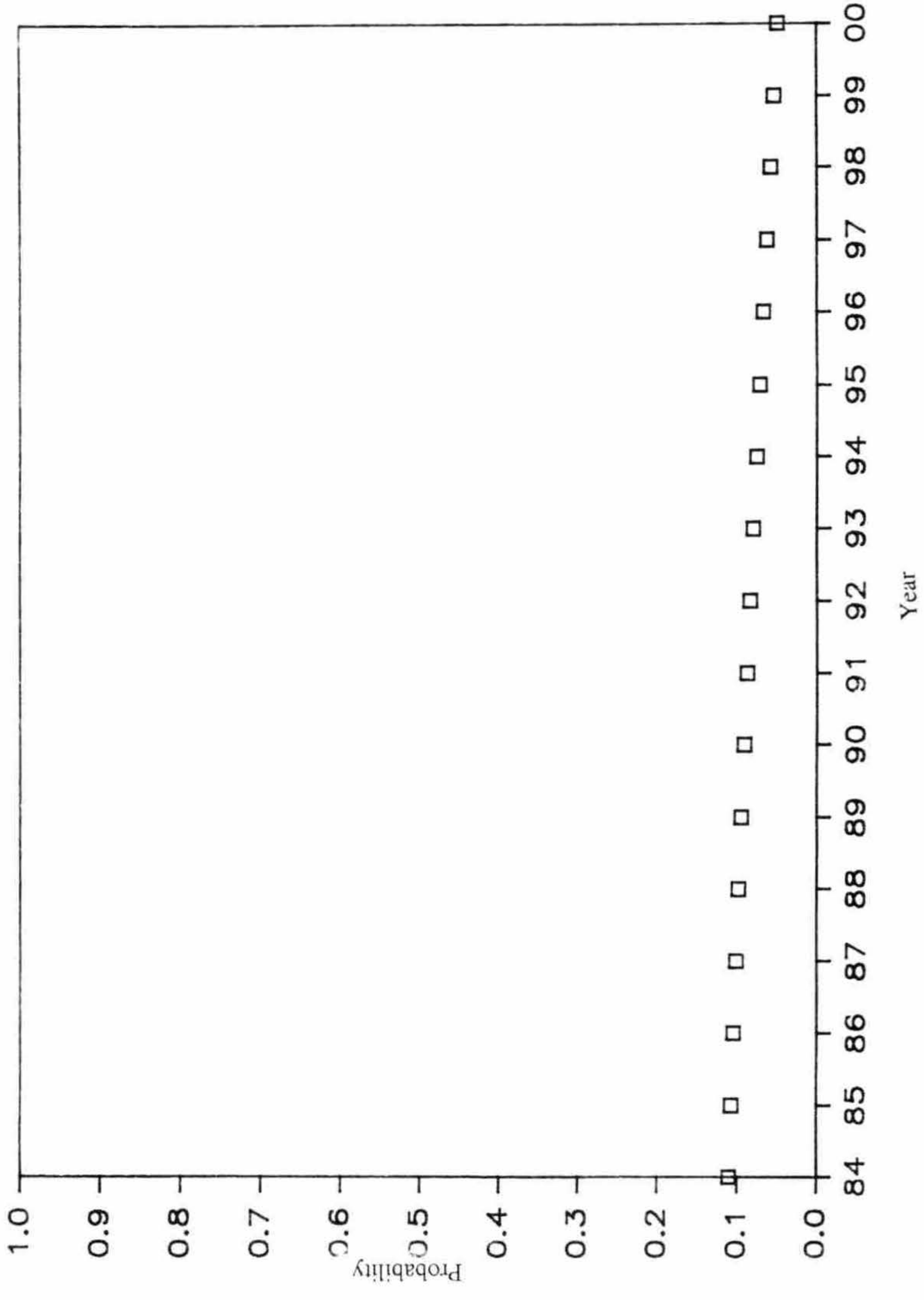
Fig. 10. 5% export value decrease. Plot of predicted probability


Probability
Year
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
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not just to corn production. Thus, the production of other foodstuffs are increasing with the increase in corn production. This could be accomplished because of better land managment and better inputs such as fertilizer.

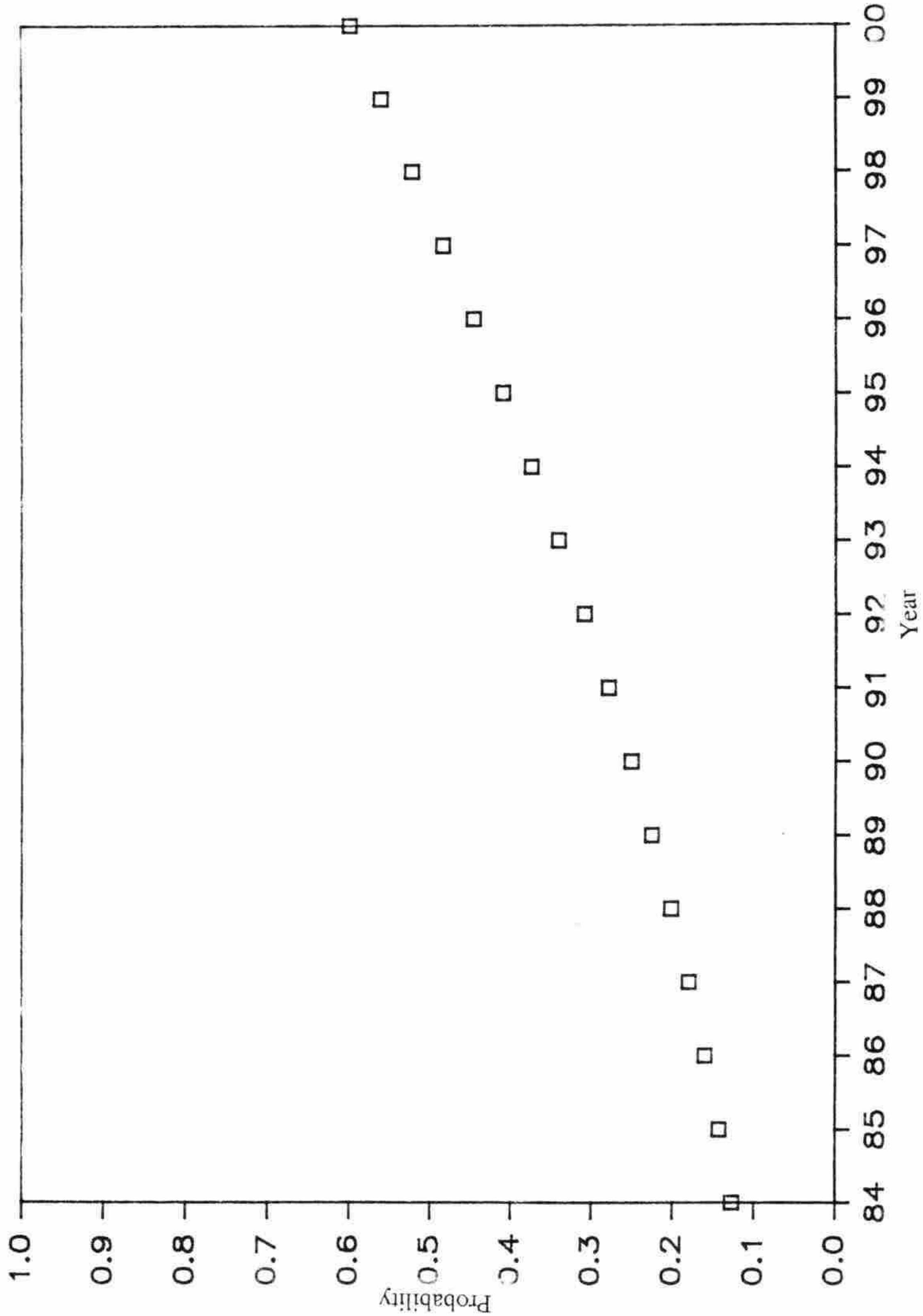
Changes in export value

The value of export goods variable (EXPORT) was increased this scenario by a five percent per year, and decreased by five percent per year (Figs. 9 and 10). The increase in export values by five percent had only a small effect on the probability of food security, increasing it from about eleven percent to twelve percent in the projection period. The value of VSFEV is small, and VSF is increasing with population growth, holding the increase in food security probability caused by EXPORT down. The effect of a fall in EXPORT on food security probability is more significant, decreasing the probability from eleven percent to about five percent in the projection period. This fall is enhanced by the increasing value of VSF due to the population increase over time. The value of export does not have a significant effect on food security probability because export income does not have to be used for the purchase of food. Thus, increasing the value of export does not necessarily result in higher levels of food security probability.

GDP changes

Changes in real GDP less exports (PCGDPEX) for this scenario where a one percent increase and decrease per year, and a .5 percent increase and decrease per year (Figs. 11, 12, 13, and 14). Growth in PCGDPEX has the expected positive effect on food security probability. As before, effects on food insecurity probability from decreases in PCGDPEX are enhanced by the value of shortfall changes, and effects of increases in PCGDPEX on food security probability are decreased by the increase in VSF. Decreases food security

Fig. 11. 1% GDP growth. Plot of predicted probability



Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Year
84
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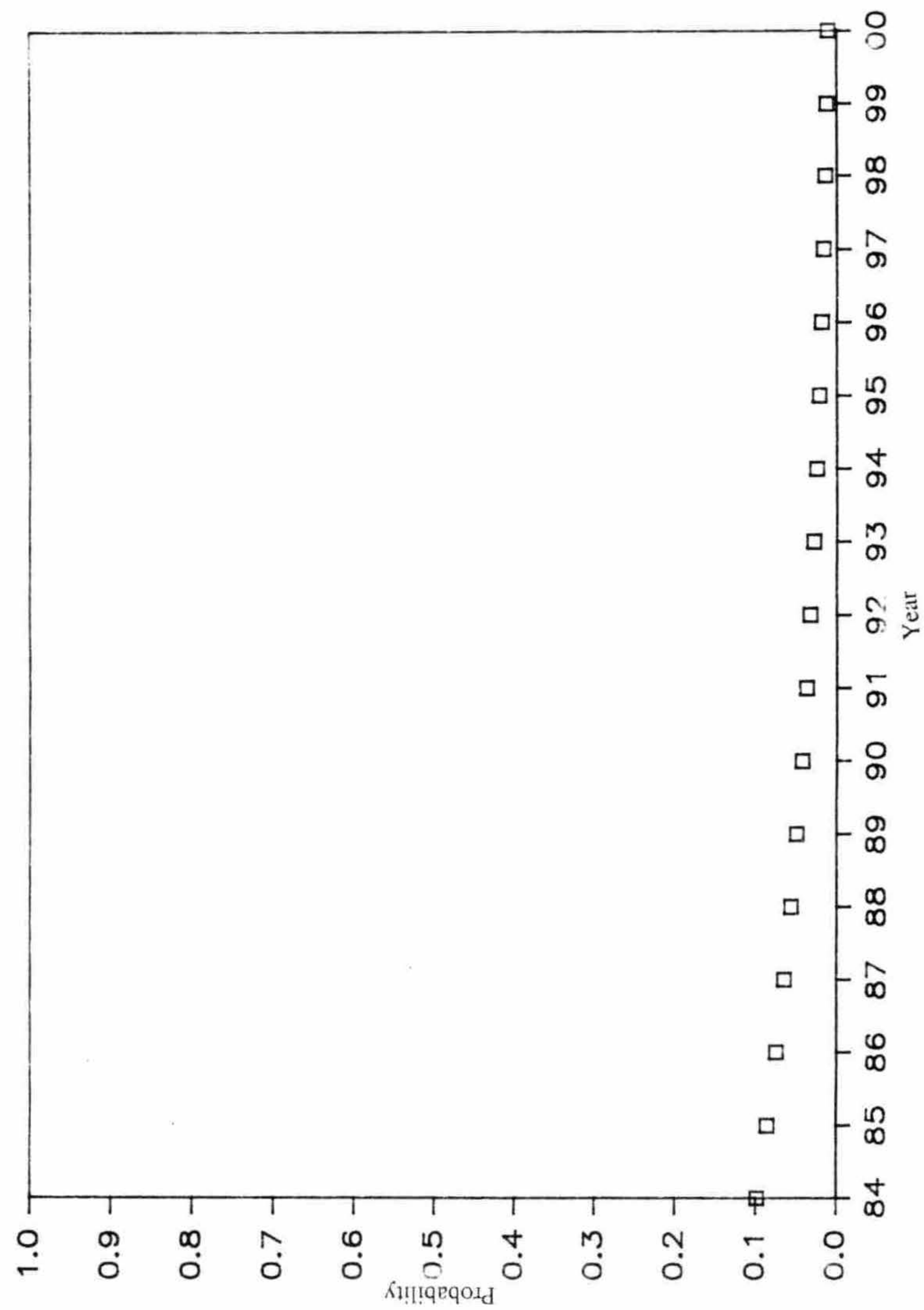
Fig. 12. 1% GDP decrease. Plot of predicted probability


Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
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0.1
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Year
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Fig. 13. .5% GDP growth. Plot of predicted probability

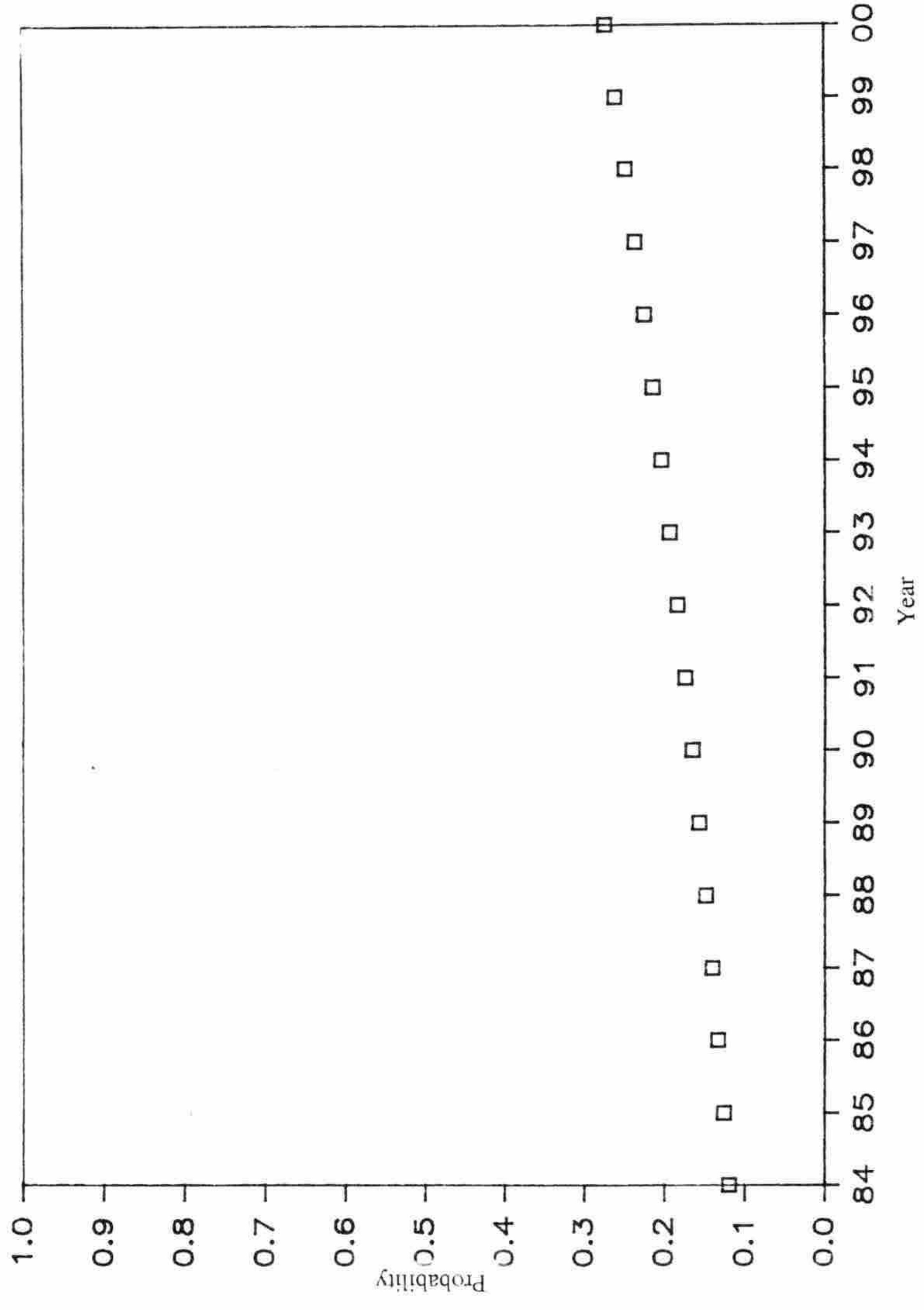
Probability
Year
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
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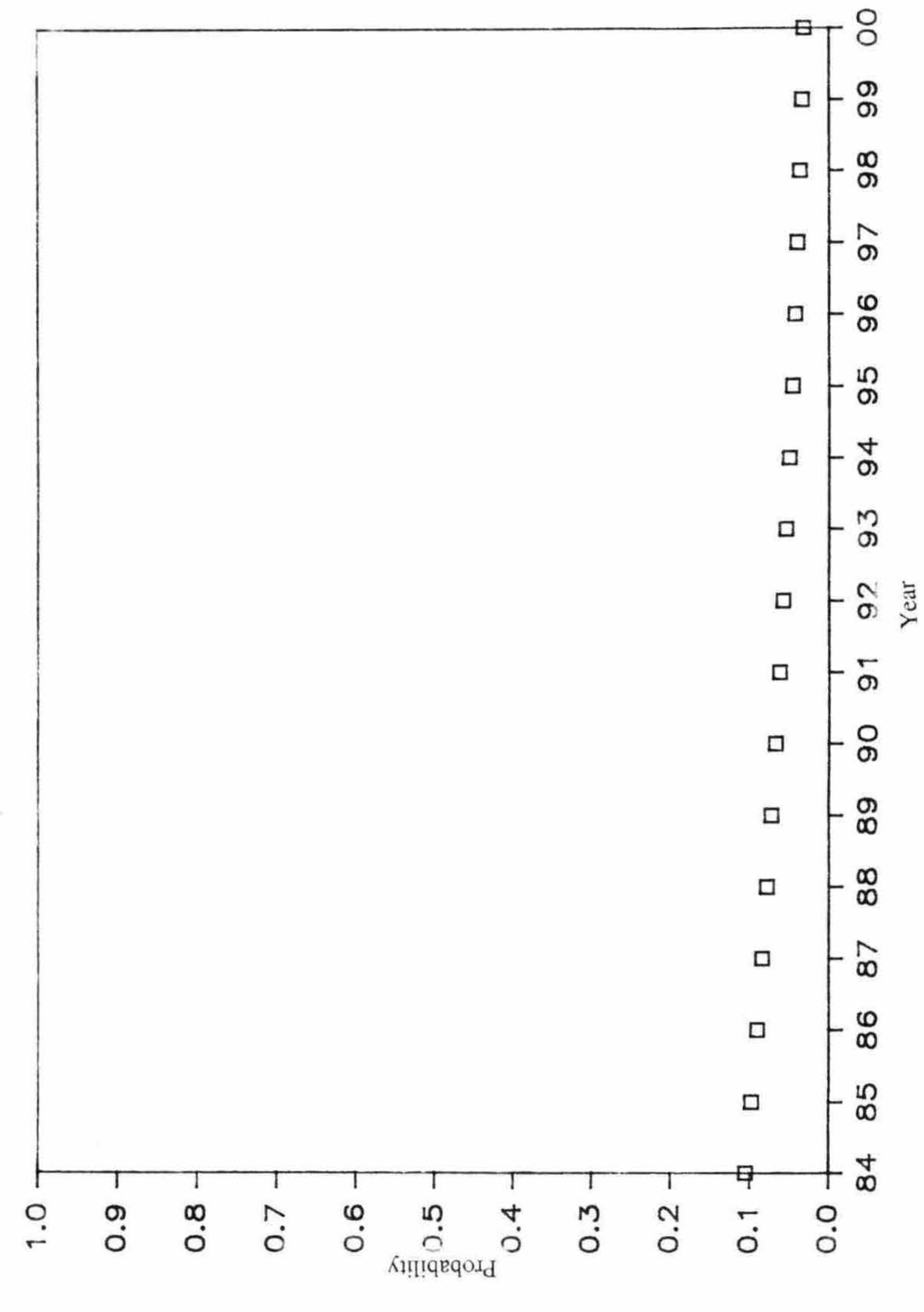
Fig. 14. .5% GDP decrease. Plot of predicted probability


Probability
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Year
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probability start at about ten percent for both .5 percent and 1 percent GDP decreases, and decrease to near zero by the year 2000.

The increase of .5 percent in PCGDPEX increases the probability of food security to about twenty-seven percent by the year 2000, but this is not significant to recommend as a policy goal. The one percent increase per year in PCGDPEX causes a steady increase in probability, but the probability goes over the fifty percent level only in 1998. All in all, PCGDPEX can have an important effect through its ability to hold food in the country and increase real purchasing demand, but the scenarios did not show enough of an increase to provide an adequate level of food security probability. Also, because of poor transport and marketing systems, any increase in income may not be translated into increased food supply to the people.

CHAPTER 3. MODEL SIMULATION

Scenario

In this chapter, several likely scenarios will be examined, first with certain values of foodstuff production, and then with production exhibiting variability similar to that of the historical period (see Appendix D). For this study, a probability of 50 percent or greater indicates food security (see Pindyck and Rubinfeld, 1981).

Optimistic

In the optimistic scenario, the values of the parameters are increased to show the effects of dramatically improved economic events in Guatemala (Fig. 15). (See Appendix D.) Increases in MP, PCGDPEX, CALGDPD, and EXPORT are all significant. Under this scenario, the fifty percent probability level is reached quickly, by the year 1987, and continues to climb to the 100 percent level throughout the remainder of the period. The optimistic scenario was designed to capture the positive trends in the independent variables.

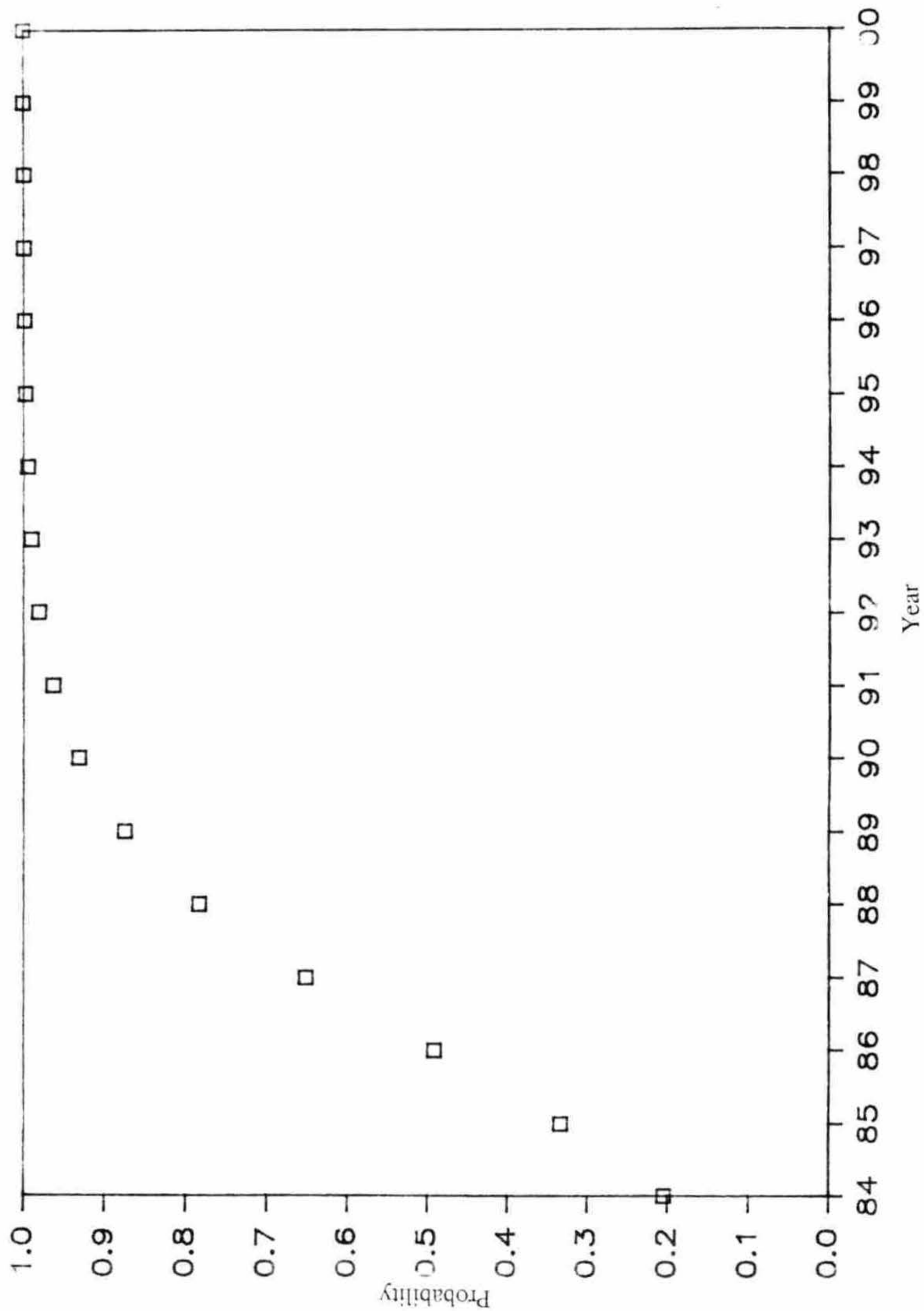
Trade income increase

In this scenario, the values of EXPORT and CALGDPD are increased by five percent per year, and modest growth in MP (to capture historical growth rates in MP) is assumed (Fig. 16). PCGDPEX is held constant for this scenario because export value is not included in GDP. The results are that the fifty percent level of probability is reached in 1993, by steady increase, and the probability increased steadily afterward, reaching eighty percent by the year 2000. This scenario shows the importance of trade on food security.

Pessimistic

In this scenario, CALGDPG, PCGDPEX, and EXPORT fall at a significant rate (Fig. 17). This scenario was used to capture recent trends in these variables to examine what

Fig. 15. Optimistic. Plot of predicted probability


Probability
Year
1.0
0.9
0.8
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0.6
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0.3
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0.1
0.0
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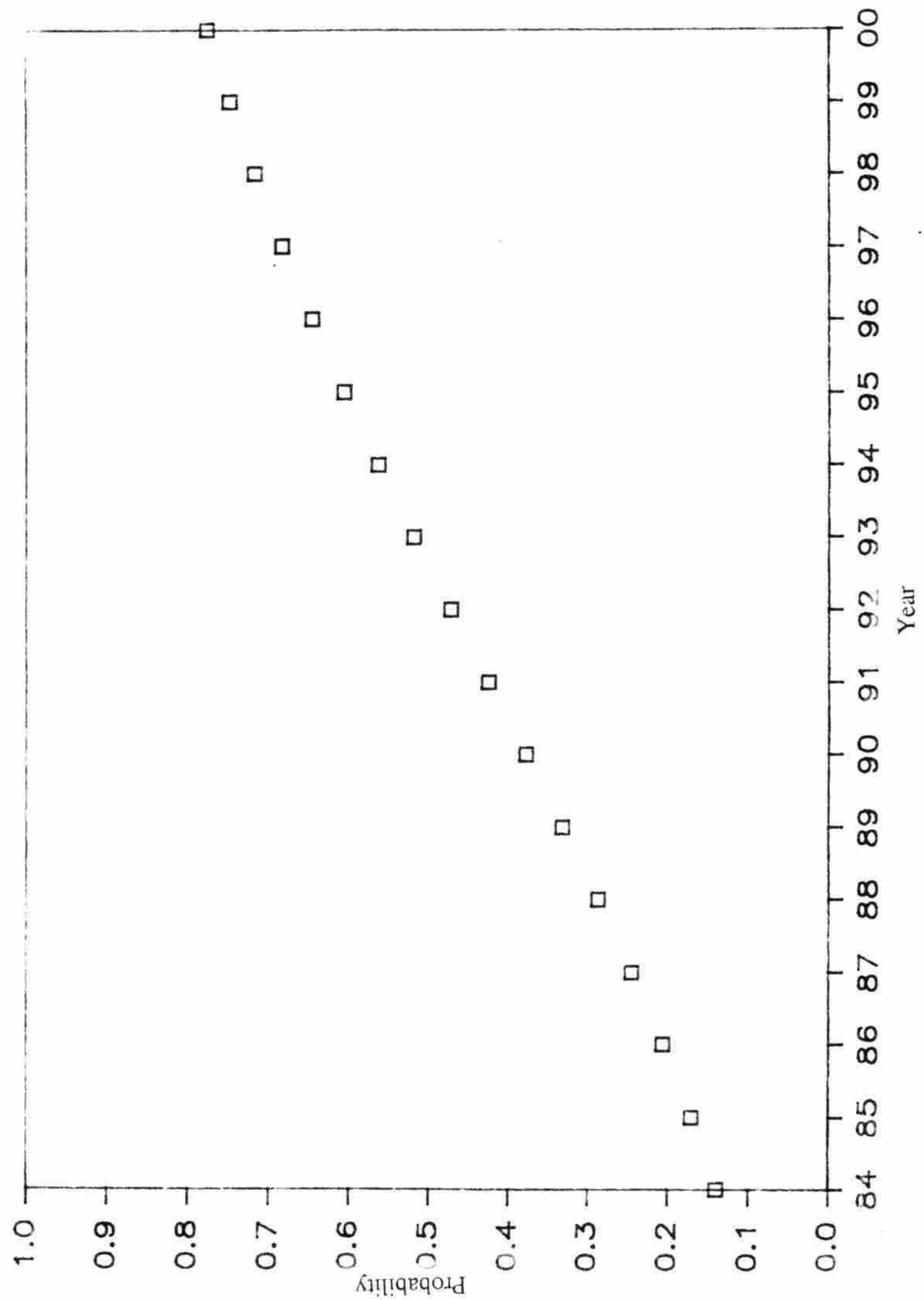
Fig. 16. Trade increase. Plot of predicted probability


Probability
Year
0.0
0.1
0.2
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0.5
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0.7
0.8
0.9
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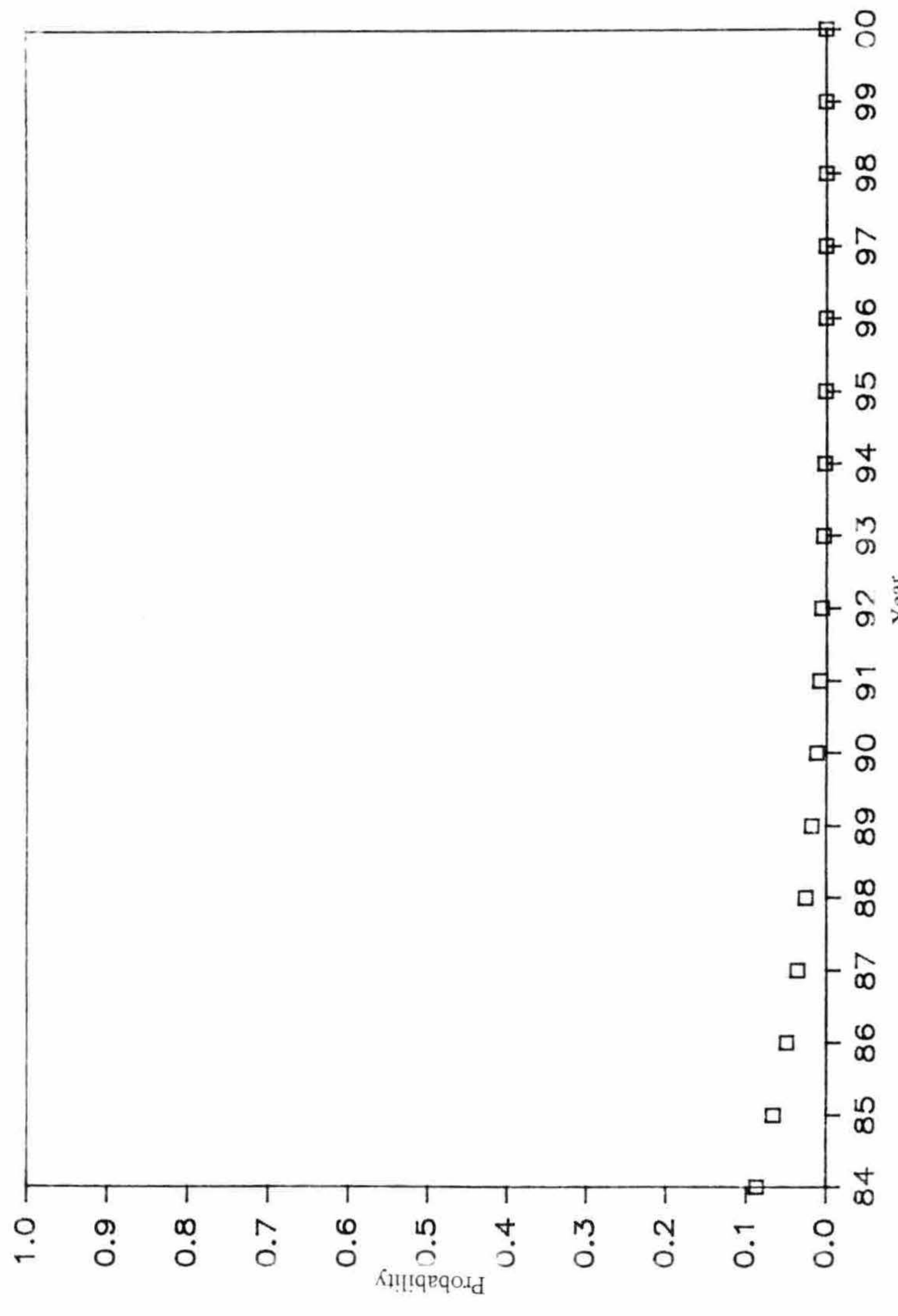
Fig. 17. Pessimistic. Plot of predicted probability



Probability
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
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effect they might have if they continue. The probability starts out at about nine percent, and falls to near zero by the year 2000. Therefore, if the downward trends in macroeconomic variables continue, there is little hope for food security unless outside forces intervene.

Trade income decrease

In this scenario, the values of CALGDPD and EXPORT fall by five percent per year, while PCGDPEX is held constant, and MP increases by .25 percent per year (Fig 18). The results of this scenario are similar in nature to the pessimistic scenario, with the probability starting out at eleven percent, and ending up at three percent in the year 2000.

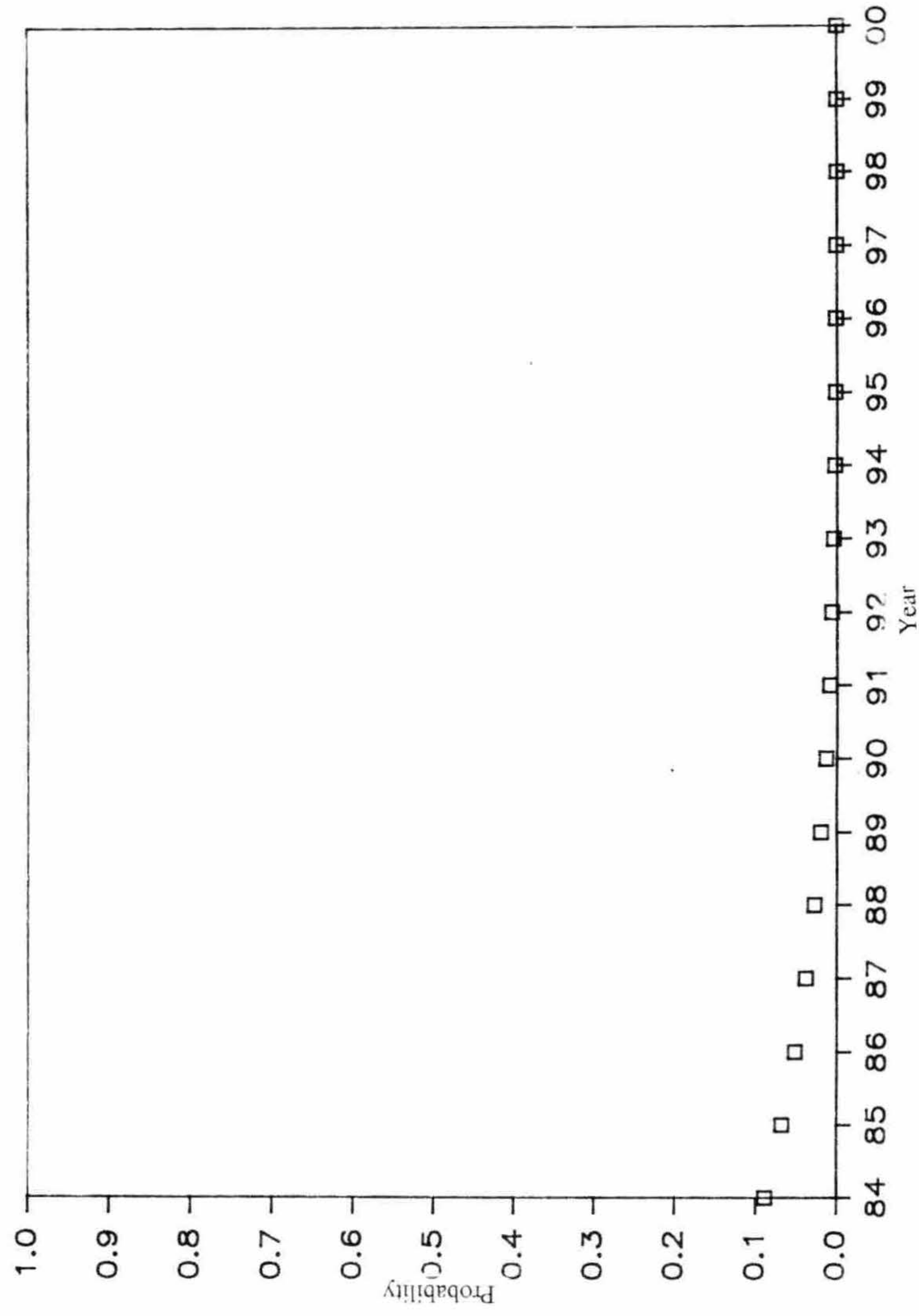
Variable Production Case Studies

The previous case studies assumed that production was certain over time, or that production of corn and other food products increased steadily and without variation over time. In this section, the variance of the historical period of this study will be applied to production of corn. Corn production MP will be allowed to grow at the same rate as population, about 2.75 percent per year, but the variance will be positive, not zero as previously assumed.

Baseline

In the baseline scenario, with values of the independent variables held at 1983 levels, the probability of food security is low, with only about thirty percent of the years at food security levels (Fig. 19). This is actually more optimistic than the non-variable production baseline, because the variance in production increases the probability significantly in several years. The plot of probability shows that only in years of very high production of food is food security possible with current trends in economic events.

Fig. 18. Trade decrease. Plot of predicted probability



Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Year
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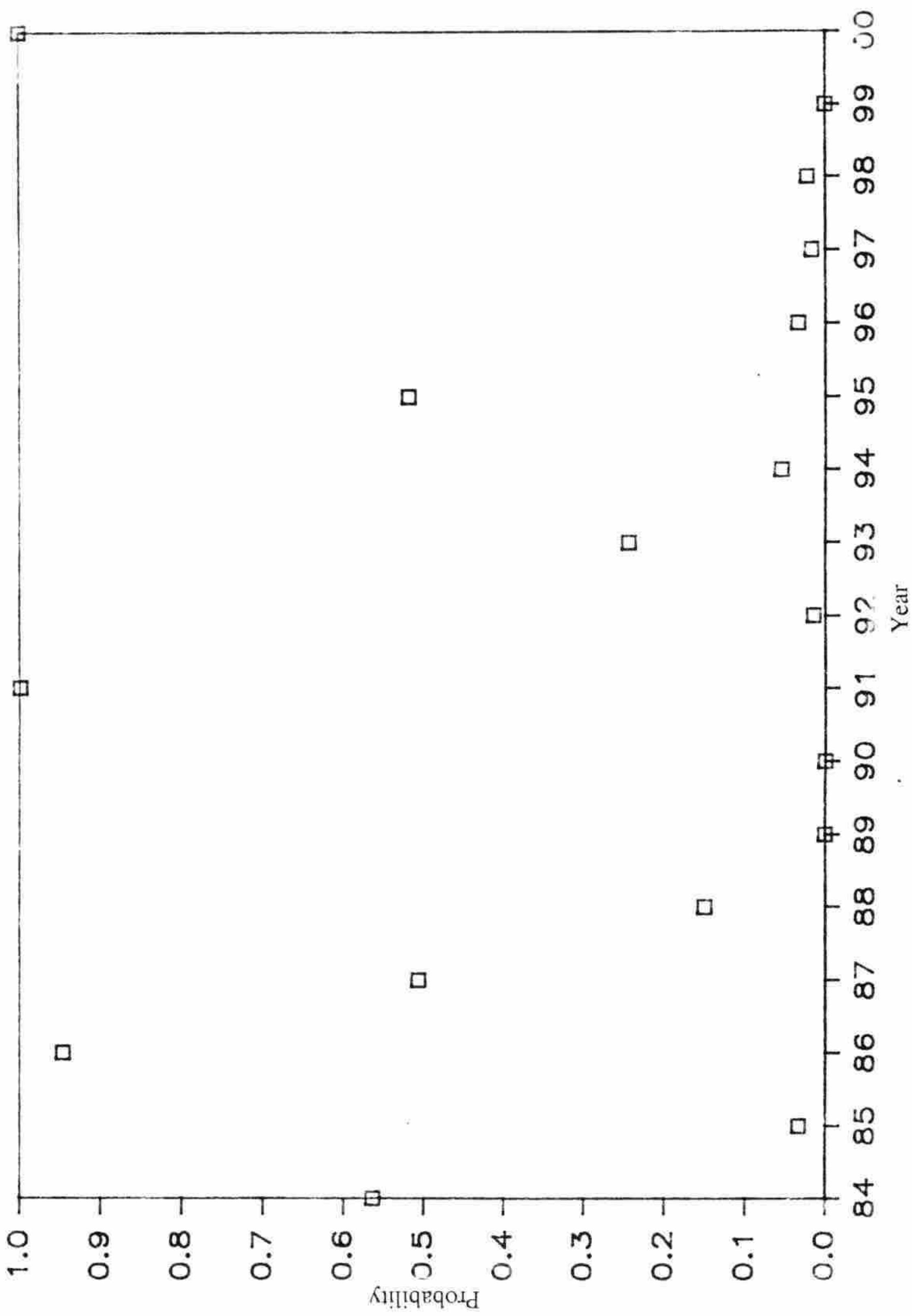
Fig. 19. Variable production baseline. Plot of predicted probability


Probability
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
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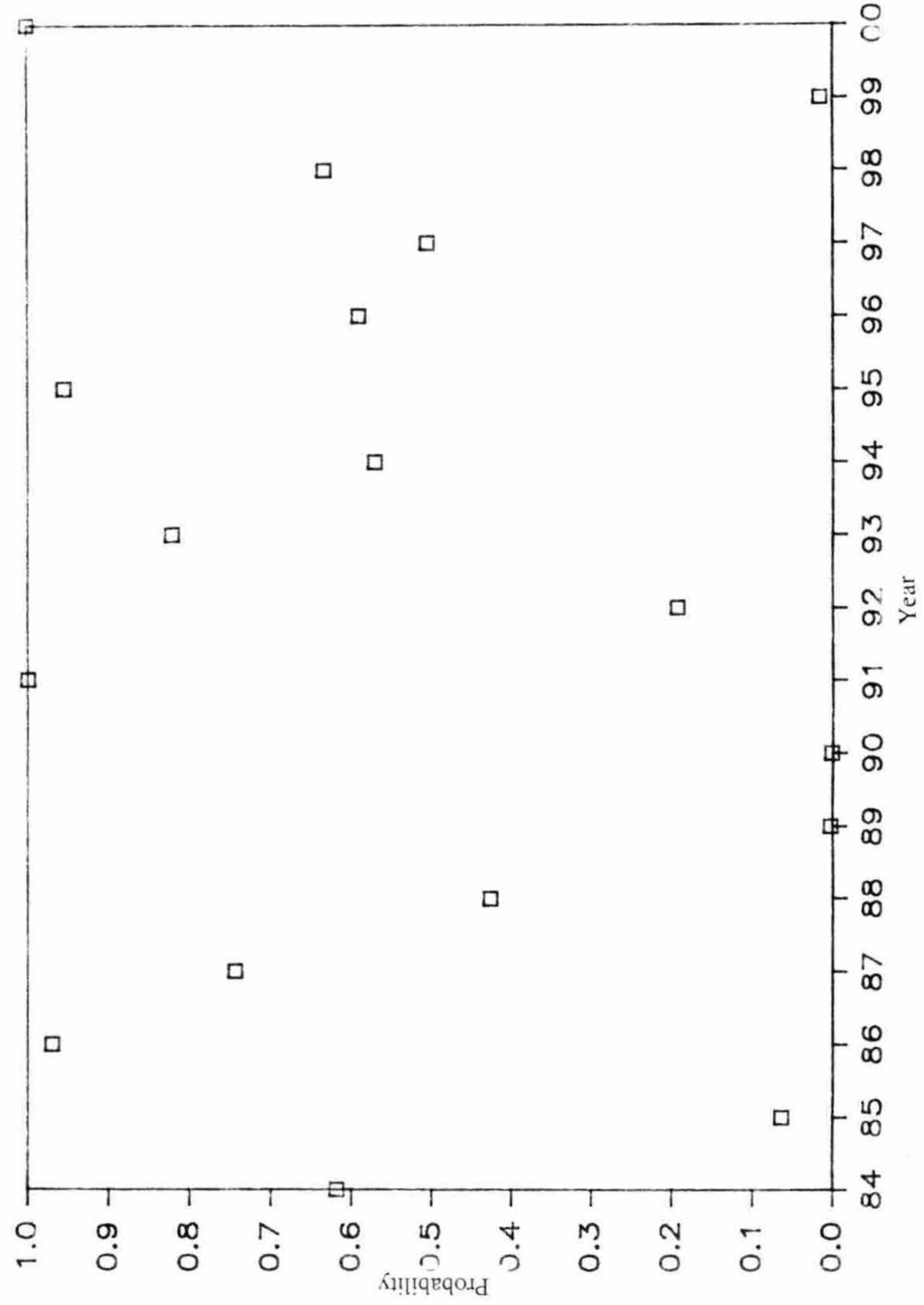
Fig. 20. Variable production optimistic. Plot of predicted probability


Probability
Year
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
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Optimistic

In the optimistic scenario, the macroeconomic variables effect on the probability of food security move several of the years to the fifty percent level, and in the later years, after the trends in trade value take over, several years are closer the the fifty percent level, as compared to the baseline (Fig. 20). This scenario shows, however, that the variability in production has a negative effect on food security. As compared to the non-variable production case, there are less food secure years in the variable production case. Therefore, in this scenario, variability has a negative effect on the probability of food security.

Pessimistic

In the pessimistic scenario, only a few years with very high production will reach food security levels. The decrease in income, exports, and current account holds the probability of food security to very low levels. Under this scenario, little hope of food security is evident. Presumably, with less trade income, less food production inputs could be purchased, causing food production to decrease over time, i.e., mean trend production would fall.

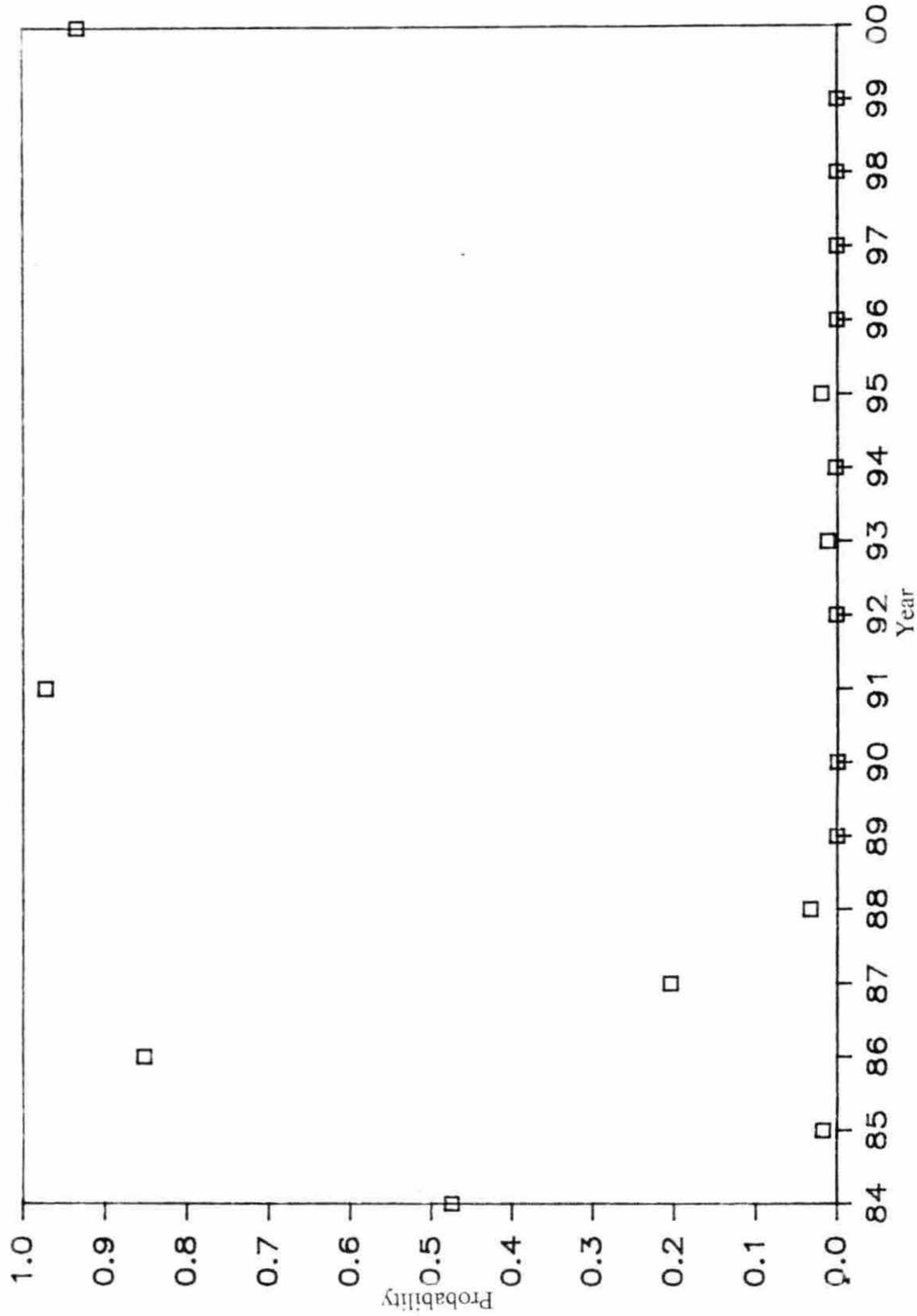
Trade income decrease

In the trade income decrease scenario, again, only a few years has the probability of food security gone above the fifty percent level (Fig. 22). The trade income decrease holds the probability down, especially in the latter part of the period when the export values and current account are much greater than the earlier part of the projection period. Again, less trade income could cause food production to decrease due to less production inputs such as fertilizer.

Trade income increase

In the trade income increase scenario, the number of times food security levels reach the fifty percent level are increased, but in other years, the probability remains low (Fig. 23). The trade income increase has more effect in the later part of the projection period after the trends take effect, but generally does not raise the probability of food security to the needed levels.

Fig. 21. Variable production pessimistic. Plot of predicted probability


Probability
1.0
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Year
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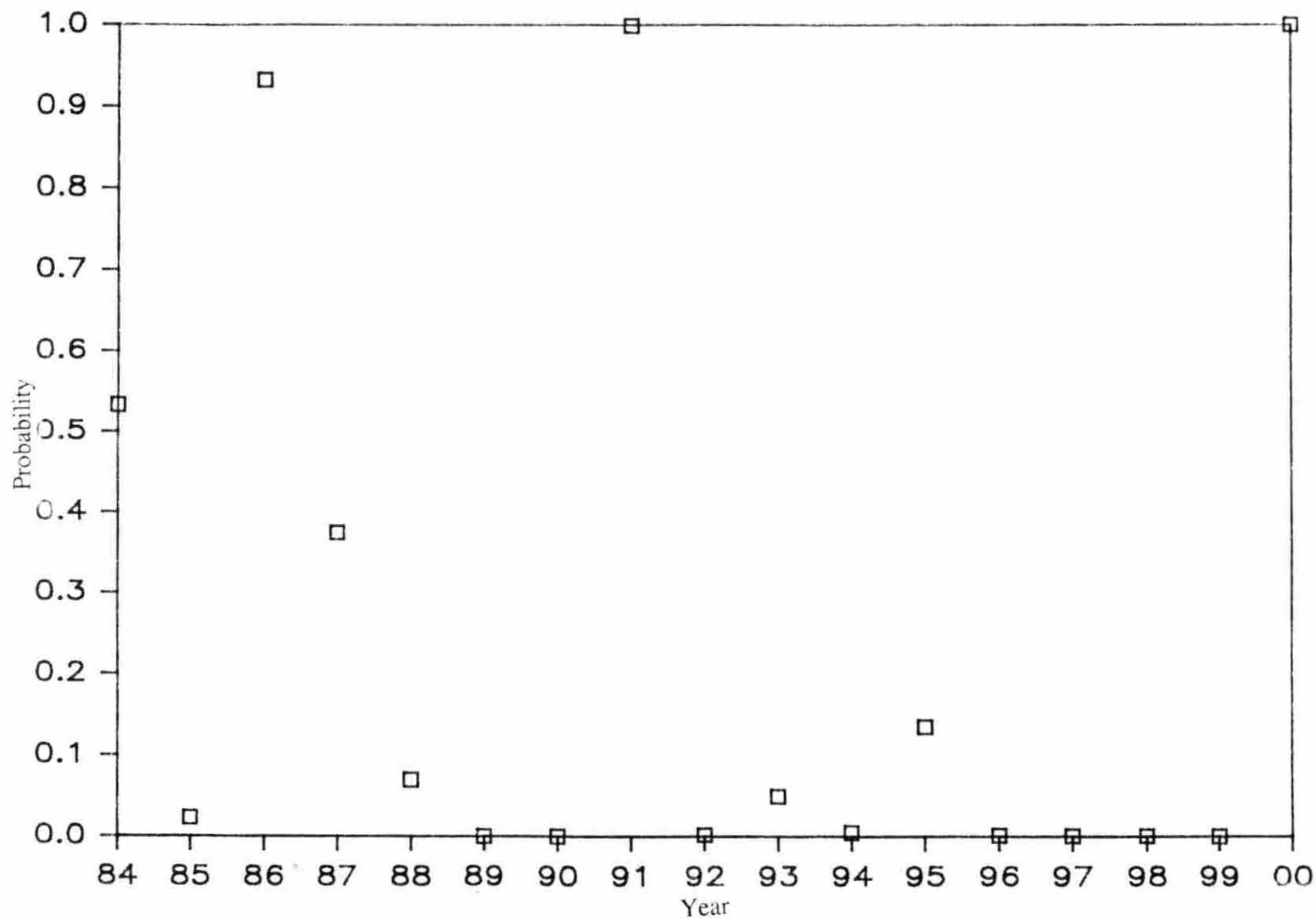
Fig. 22. Variable production trade decrease. Plot of predicted probability


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Probability
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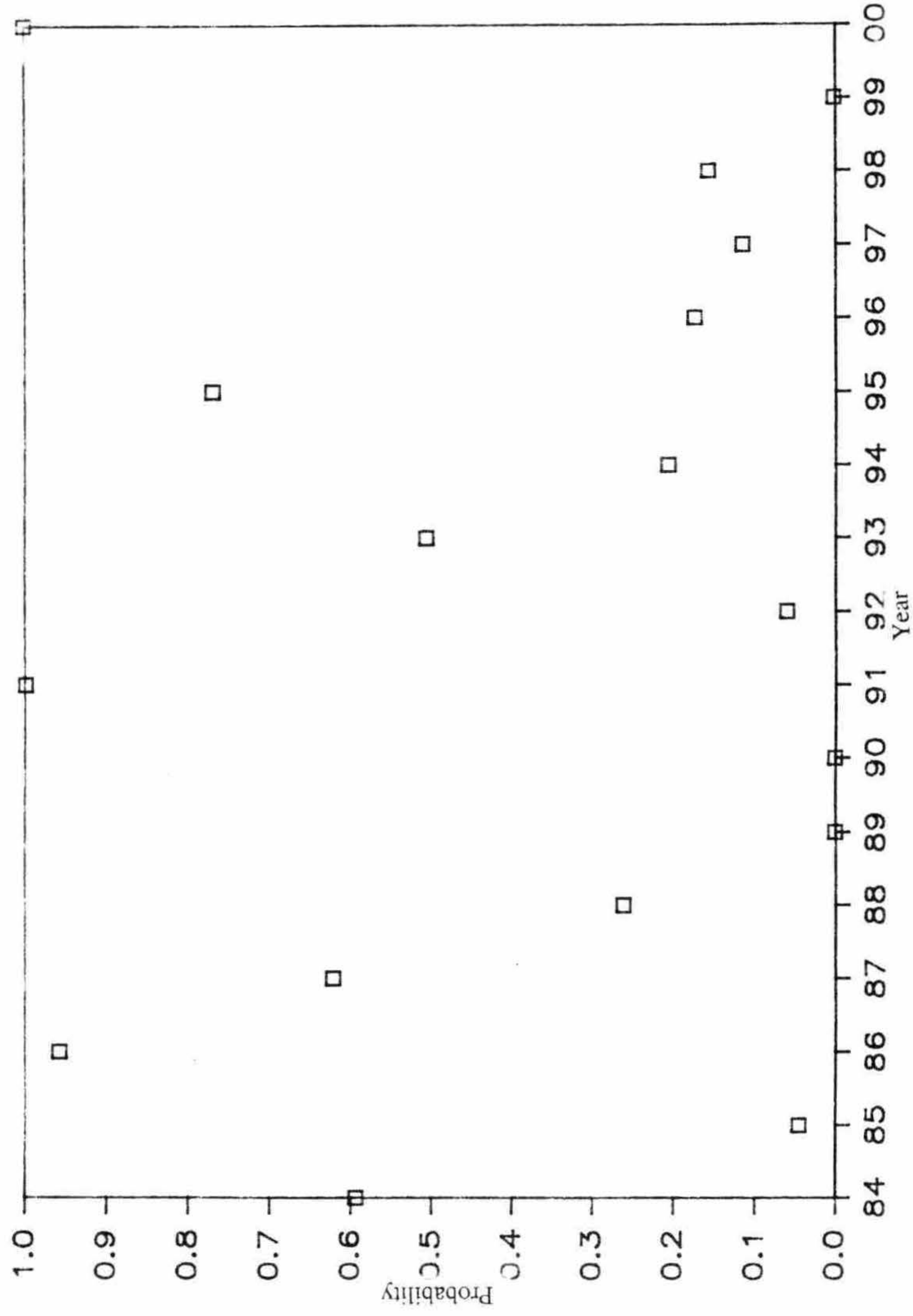
Year

Fig. 23. Variable production trade increase. Plot of predicted probability


Probability
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
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CHAPTER 4. CONCLUSIONS

This study was designed to measure the effects of macroeconomic variables on the probability of food security for Guatemala. An empirical model was developed because previous studies of food security use variables that have less economic appeal. Variables that are important to food security are the real current account balance, production of corn, real GDP less exports and the ratio of the value of shortfall to the export value. With a model of the probability of food security specified with these variables, it is possible to predict the probability of food security given projections in the macroeconomic variables. These projections were first carried out with certain corn production, with results being that food production had the largest effect on the probability of food security, and that income growth is also very important. Production growth in the basic grains provides more food to the rural community, and also, more food is available for sale to the urban sector. Income growth increases the probability of food security by increasing the purchasing power of the country, allowing Guatemala to more effectively use its production potential to feed itself. The real current account balance effects food security by changing trade patterns to crops that generate more income per unit of land area, and also by changing the ability to purchase food on the world market. Crops such as cotton and coffee will help generate foreign exchange to reduce the current account deficit, but the land area used for these crops will decrease land available to produce the basic grains. The ratio of the value of shortfall to export value variable effects food security by decreasing Guatemala's ability to purchase food on the world market.

With uncertain production, the model results change significantly. The production variability generally reduces the probability of food security, because of the relatively large production shortfalls that will occur. The variable production case studies show that, with "realistic" variability in production, it is less likely that Guatemala will be food secure in the next few years. It is difficult to say ex ante, how the variability in food production effects Guatemala. Clearly, if production is known with certainty, stock programs could be implemented to carry-over food between time periods. In this case, variability in food production is not "bad." However, if the variability is now known, then uncertainty will cause resources to be mis-allocated (both monetary and production resources), and will cause Guatemala to be less food secure.

CHAPTER 5. RESULTS AND RECOMMENDATIONS

Several policy recommendations come from this analysis. First, Guatemala must place emphasis on increasing the production of foodstuffs, and at the same time, create a stronger effective demand for these foodstuffs to provide production incentives to the farmers. This increase in production must be achieved without significantly reducing the land area available to produce export crops, since these export crops will continue to provide foreign exchange to Guatemala. This would indicate either production increases through yield increases, or the development of land not currently used in production through irrigation. Second, the balance of trade problems must be reduced. Since a negative balance of trade decreases the probability of food security through changing trade patterns, the recent sharp negative trends in trade balance need to be reversed. This could be accomplished by producing some of the goods that were previously imported, and by more efficient purchasing of import goods. Third, the level of debt must be reduced, because of the pressure that debt places on the trade patterns of the country.

Further Research

This analysis clearly shows that macroeconomic variables and food production variables are important in the determination of food security in Guatemala, and that by changing the variables, the level of food security probability can be altered. This result is not specific to Guatemala, and has several possible extensions. First, an extension would be to perform this analysis on other less developed countries. Many less developed countries have difficulties similar to Guatemala, and this type of analysis could be used to quantify the effects, and then recommend policy alternatives. Second, the analysis could be performed on a regional level. In the economic area of Central America, an analysis of the type could be performed to see it, on a regional basis, food security could be obtained through intercountry trade of food and other goods, as well as co-management of debt and trade. Third, this type of analysis could be used to quantify the tradeoff between the emphasis on export goods production and the production of foodstuffs, and their relationship to food security.

BIBLIOGRAPHY

Anderson, Jock R.and Scandizzo, Pasquale, L. "Food Risk and the Poor." Food Policy 9, No. 1 (February 1984):44-52.

Bachman, K. L., and Paulino, L. A. "Rapid Food Production Growth in Selected Developing Countries: A Comparative Analysis of Underlying Trends, 1961-76." Research Report 17. International Food Policy Research Institute, Washington, D.C., 1979.

Fletcher, Lehman B; Graber, Eric; Merrill, William; and Thorbeck, Erik. Agricultural Development Policy in Guatemala. Ames: Iowa State University Press, 1969.

Food and Agricultural Organization of the United Nations. FAO Trade Yearbook. Rome: FAO, 1983.

Green, Christopher, and Kirkpatrick, Colin. "A cross-section analysis of food in security in developing countries: Its magnitude and sources." Journal of Development Studies 18, No. 2 (January 1982):185-204.

Ibañez, Eduardo. Estudio de Seguridad Alimentaria Marco Cuantitativo, Version Guatemala. Guatemala: Ibañez, 1985.

Institute of Nutrition of Central America and Panama, and the Interdepartmental Committee on Nutrition for National Development. Nutritional Evaluation of the Population of Central America and Panama 1965-1967. Guatemala: INCAP, 1981.

International Monetary Fund. International Financial Statistics 1983. Washington D.C.: International Monetary Fund.

La Secretaría Permanente del Tratado General de Integration Economica Centroamericana. Series Estadisticas Seleccionadas de Centroamerica #16. Guatemala: SIECA, 1980.

La Secretaría Permanente del Tratado General de Integration Economica Centroamericana. Series Estadisticas Seleccionadas de Centroamerica #19. Guatemala: SIECA, 1984.

Pindick, Robert S. and Rubin Feld, Daniel L. Econometric Models and Econometric Forecasts. Second edition. Tokyo: McGraw-Hill, 1981.

Roumasset, James. "Rural Food Security." In Food Security: Theory, Policy, and Perspectives from Asia and the Pacific Rim, pp. 129-141. Edited by Anthony H. Chisholm and Rodney Tyers. Lexington: D.C. Heath and Company, 1982.

Valdés, Alberto and Konandreas, Panos. "Assessing Food Insecurity Based on National Aggregates in Developing Countries." In Food Security for Developing Countries, pp. 23-51. Edited by Alberto Valdés. Boulder: Westview Press, 1981.

Valverde, Víctor; Delgado, Hernán; Flores, Rafael; and Sibrián, Ricardo. Nutritional and Health Consequences of Seasonal Fluctuations in Household Food Availability. Guatemala: INCAP, 1985.

Yumiseva, Hilda. "Food Security in Latin America: Recent Trends and Policy Issues." Paper presented at the Ministerial Consultation on Food Policies and Strategies in Latin America and the Carribbean, Quito, Ecuador. April 25-27, 1983.

APPENDIX A. CONSUMPTION DATA

Year	CORNC[1]	BEANC[2]	RICEC[3]	SORGHUMC[4]	VEGC[5]
1960	1357	191	35	34	162
1961	1339	187	31	36	159
1962	1429	187	39	36	169
1963	1673	234	43	54	200
1964	1722	242	56	58	208
1965	1664	239	64	90	206
1966	1650	232	68	65	202
1967	1441	137	49	68	170
1968	1405	125	52	81	166
1968	1414	115	292	90	165
1970	1502	115	47	76	174
1971	1347	114	50	92	160
1972	1436	100	60	71	167
1973	1522	119	46	74	179
1975	1209	91	33	97	143
1975	1244	105	54	138	154
1976	874	60	17	140	109
1977	932	56	34	125	115
1978	1367	117	46	95	163
1979	1538	110	50	99	180
1980	1316	76	44	101	154
1981	1392	119	49	108	167
1982	1392	122	65	94	167
1983	1419	126	64	126	174

[1]Corn apparent consumption. Calories per capita per day.

[2]Bean apparent consumption. Calories per capita per day.

[3]Rice apparent consumption. Calories per capita per day.

[4]Sorghum apparent consumption. Calories per capita per day.

[5]Vegetable products consumption. Calories per capita per day.

MEATC[6]	MILKC[7]	SUGC[8]	TOTALC[9]	YN	CORNP[10]	YEAR
57	79	41	1956	0	1.36	1960
55	77	42	1926	0	1.31	1961
51	77	42	2024	0	1.31	1962
56	76	42	2378	1	1.39	1963
54	77	45	2462	1	1.42	1964
50	78	49	2240	1	1.43	1965
50	78	51	2396	1	1.45	1966
50	74	49	2038	0	1.22	1967
51	75	49	2004	0	1.30	1968
51	74	50	1988	0	1.42	1969
50	74	50	2088	1	1.56	1970
50	74	52	1939	0	1.34	1971
53	74	55	2016	0	2.17	1972
43	72	60	2145	1	3.12	1973
41	68	58	1740	0	3.34	1974
45	66	66	1806	0	3.03	1975
47	66	66	1379	0	2.86	1976
45	70	70	1447	0	2.42	1977
43	71	67	1969	0	2.56	1978
40	72	68	2157	1	2.93	1979
36	72	77	1876	0	3.20	1980
32	71	69	2007	0	3.33	1981
27	68	61	1935	0	2.80	1982
24	50	60	2043	0	3.45	1983

[6]Beef consumption. Calories per capita per day.

[7]Milk consumption. Calories per capita per day.

[8]Sugar apparent consumption. Calories per capita per day.

[9]Total apparent consumption. Calories per capita per day.

[10]U.S. gulfport corn price. U.S. dollars per bushel F.O.B.

APPENDIX B. MACROECONOMIC DATA

Year	PCGDPEX[1]	MP[2]	CALGDPD[3]	VSFEV[4]	EXPORT[5]	VSF[6]	POP[7]
1960	619	1357	-71.9	.023004	116.5	2.68	3.83
1961	631	1343	-28.1	.029104	112.7	3.28	3.95
1962	640	1360	-20.4	.011467	112.5	1.29	4.06
1963	662	1646	-40.1	-.044156	154.0	-6.8	4.19
1964	667	1697	-43.3	-.05509	167.0	-9.2	4.31
1965	672	1639	-96.7	-.047726	186.9	-8.92	4.41
1966	675	1650	-89.6	-.035514	227.8	-8.09	4.50
1967	695	1429	-31.8	.0053715	199.2	1.07	4.70
1968	729	1405	-161.5	.0087955	230.8	2.03	4.84
1969	729	1414	-129.7	.010673	258.6	2.76	5.02
1970	729	1472	-47.7	-.00032864	298.2	-0.098	5.27
1971	757	1320	-18.9	.014586	298.0	4.23	5.42
1972	777	1419	-119.1	.0098375	338.5	3.33	5.58
1973	794	1460	-28.3	-.0096223	444.8	-4.28	5.74
1974	791	1091	16.5	.04770	582.6	27.79	6.05
1975	789	1159	-191.2	.032813	640.9	21.03	6.24
1976	819	864	-107.7	.066181	782.1	51.76	6.43
1977	819	913	-114.0	.034512	1182.5	40.81	6.63
1978	868	1246	-44.6	.0072750	1113.4	8.1	6.84
1978	868	1246	-44.6	.0072750	1113.4	8.1	6.84
1979	881	1461	-324.0	-.0046682	1270.3	-5.93	7.05
1980	871	1227	-226.7	.012433	1557.1	19.36	7.26
1981	906	1317	-163.3	.0061866	1252.7	7.75	7.48
1982	861	1410	-517.0	.010993	1172.6	12.89	7.70
1983	818	1417	-350.0	.0038510	1189.3	4.58	7.93

[1]Per capita GDP less export value.

[2]Corn production.

[3]Deflated current account beginning balance. Million U.S. dollars.

[4]Value of shortfall divided by export value. U.S. dollars.

[5]Export value. Millions of U.S. dollars.

[6]Value of shortfall. U.S. dollars.

[7]Total population. Million people.

Year	MPE[8]
1984	1500
1985	1371
1986	1591
1987	1491
1988	1430
1989	1198
1990	1174
1991	1715
1992	1349
1993	1451
1994	1395
1995	1490
1996	1380
1997	1358
1998	1369
1999	1183
2000	1780

[8]Expected corn production. Calories per capita per day.

Fig. B1. Plot of VSFEV and YEAR

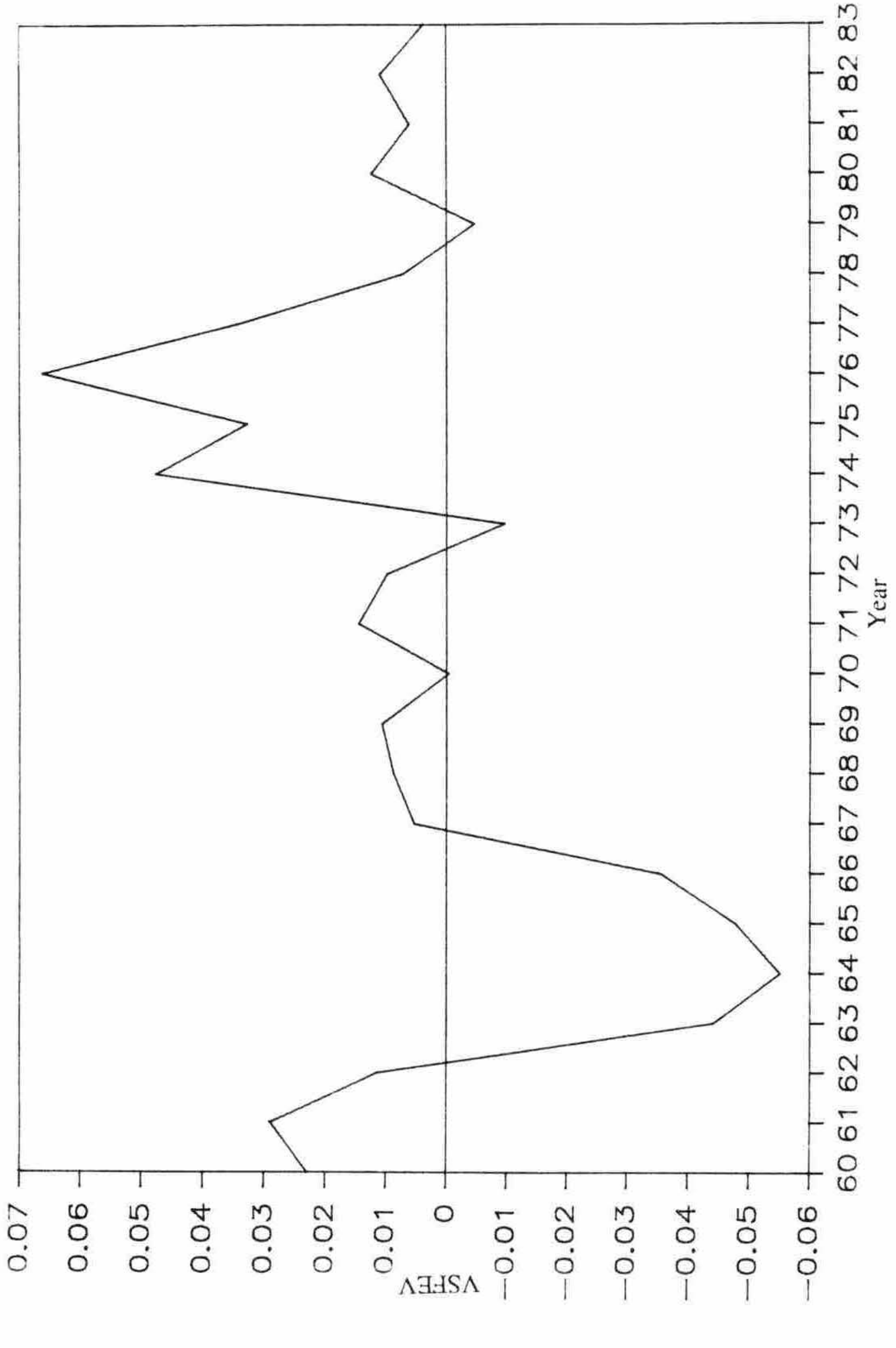

VSFEV
Year
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83

Fig. B2. Plot of MP and YEAR

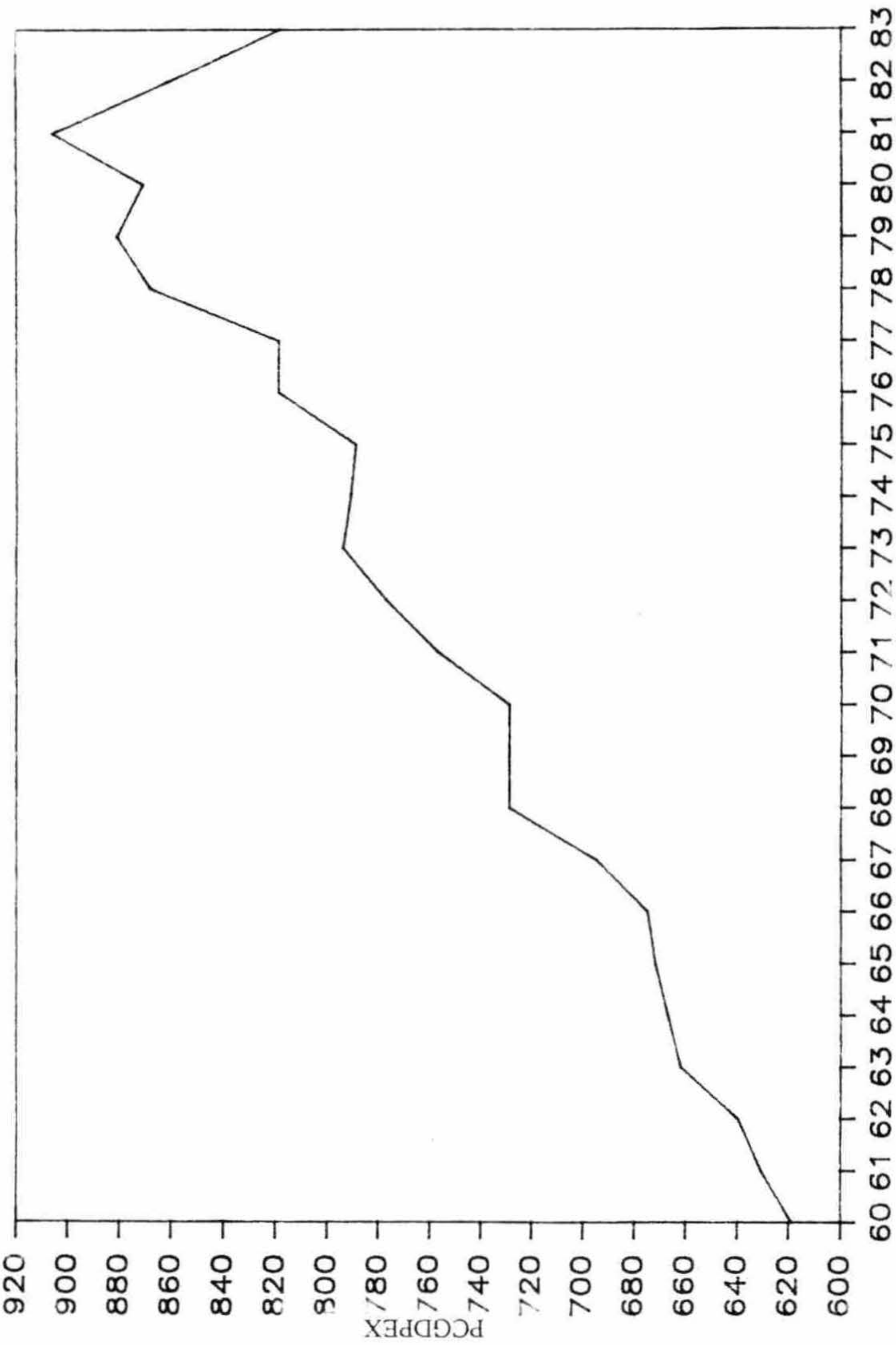
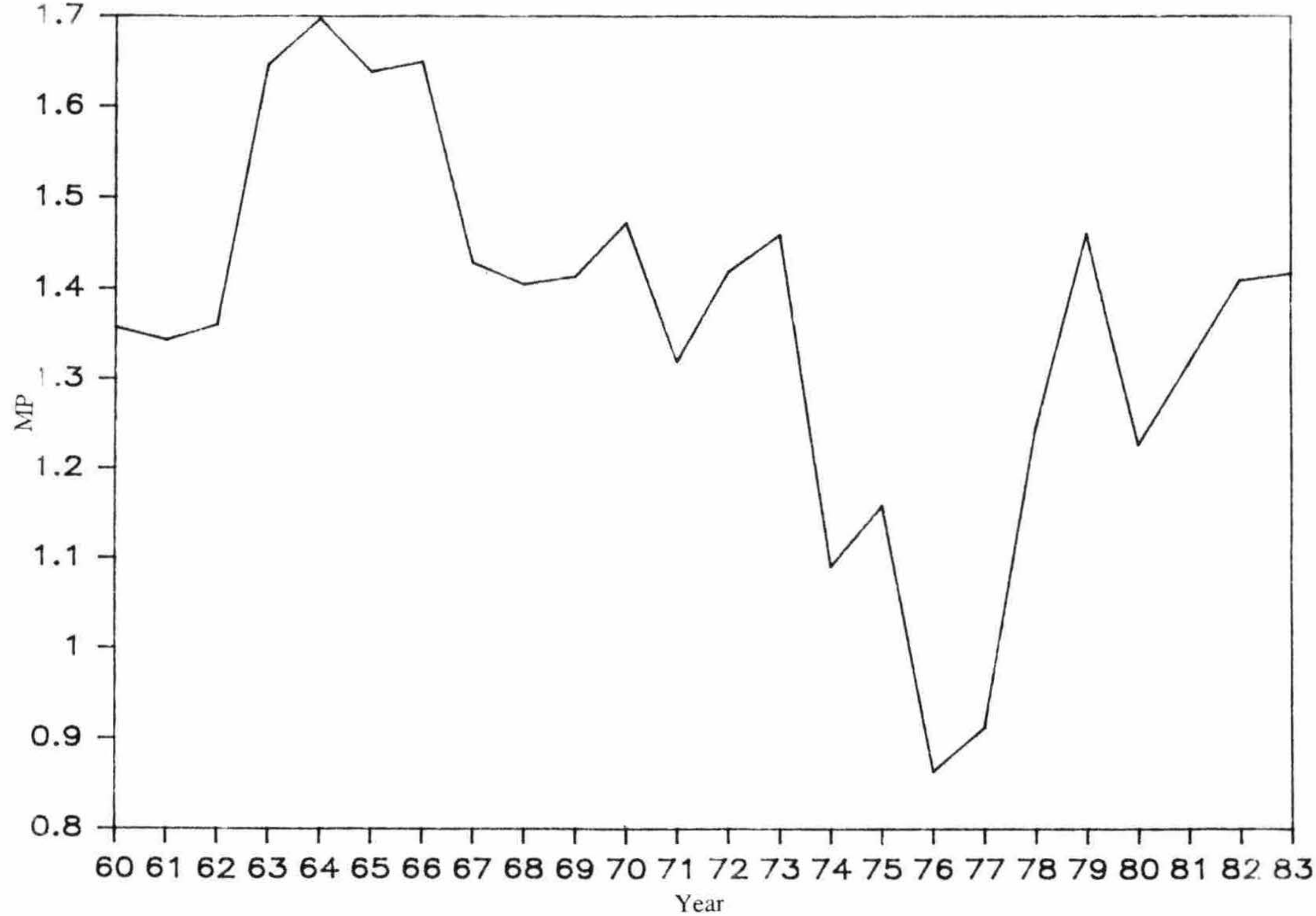
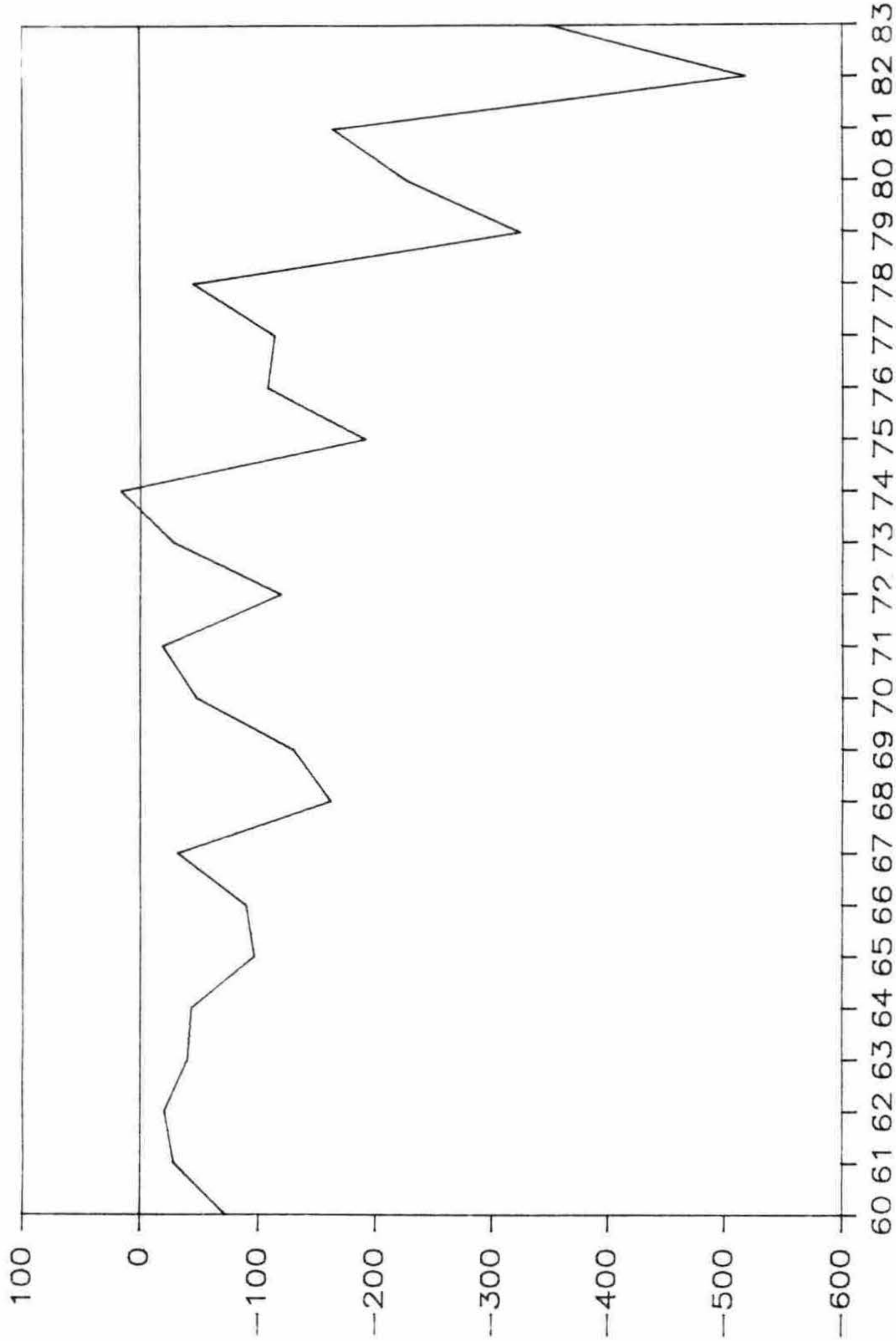

PCGDPEX
920
900
880
860
840
820
800
780
760
740
720
700
680
660
640
620
600
Year
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83

Fig. B3. Plot of PCGDPEX and YEAR



1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
MP
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83
Year

Fig. B4. Plot of CALGDPD and YEAR


CAL GDPD
100
0
−100
−200
−300
−400
−500
−600
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83
Year

APPENDIX C. VARIABLE DEFINITIONS AND SOURCES

BEANC—	Bean apparent consumption. Calories per capita per day. Agricultural Development Policy in Guatemala (ADPG) and Series Estadisticas Selectionadas de Centroamericana (SIECA), various issues.
CALGDPD—	Deflated current account beginning balance. Million U.S. dollars. International Financial Statistics, 1983.
CORNC—	Corn apparent consumption. Calories per capita per day. ADPG and SIECA, various issues.
CORNP—	U.S. gulfport corn price. U.S. dollars per bushel F.O.B. FAO Trade Yearbook, various issues.
DEBTEX—	Debt to exports ratio. U.S. dollars. International Financial Statistics.
EXPORT—	Export value. Millions of U.S. dollars. International Financial Statistics.
MEATC—	Beef apparent consumption. Calories per capita per day. ADPG and SIECA, various issues.
MILKC—	Milk consumption. Calories per capita per day. ADPG and SIECA, various issues.
MP—	Corn production. Calories per capita per day. ADPG and SIECA, various issues.
MPE—	Expected corn production. Calories per capita per day. Calculated as $x = \sqrt{-2 \text{Log } U_1} \text{Cos}(2\pi U_2)$ where U_1 and U_2 are uniformly distributed random numbers.
PCGDPEX—	Per capita GDP less export value. 1980 dollars. International Financial Statistics 1983.
POP—	Total population. Million people. International Financial Statistics, 1983.
RICEC—	Rice apparent consumption. Calories per capita per day. ADPG and SIECA, various issues.
SORGHUMC—	Sorghum apparent consumption. Calories per capita per day. ADPG and SIECA, various issues.
SUGC—	Sugar apparent consumption. Calories per capita per day. Estudio de Seguridad Alimentaria Marco Cuantitativo.
VEGC—	Vegetable products consumption. Calories per capita per day. Calculated as .1·[CORNC + BEANC + RICE + SORGHUMC].

VSF— Value of shortfall. U.S. dollars. Calculated as [2085 - TOTALC] $\cdot 365 \cdot POP \div 1635 \div 56 \cdot CORNP$.

VSFEV— Value of shortfall divided by export value. U.S. dollars. Calculated as VSF/EXPORT.

TOTALC— Total apparent consumption. Calories per capita per day. Calculated as [CORNC + BEANC + RICEC + SORGHUMC + MEATC + MILKC + VEGC + SUGC].

APPENDIX D. FIGURE DEFINITIONS

Fig.#	Fig. Name	Price[1]	Export[1]	MP[2]	PCGDPEX[1]	CALGDPD[1]	POP[1]
1	Historical						
2	Baseline	x	x	x	x	x	x
3	5% current account increase	x	x	x	x	5%↑	x
4	10% current acount increase	x	x	x	x	10%↑	x
5	5% current account decrease	x	x	x	x	5%↓	x
6	Corn production growth of .25%	x	x	.25%↑	x	x	x
7	Corn production growth of .50%	x	x	.50%↑	x	x	x
8	Corn production growth of .75%	x	x	.75%↑	x	x	x
9	5% export value increase	x	5%↑	x	x	x	x
10	5% export value decrease	x	5%↓	x	x	x	x
11	1% GDP growth	x	x	x	1%↑	x	x
12	1% GDP decrease	x	x	x	1%↓	x	x
13	.5% GDP growth	x	x	x	.5%↑	x	x
14	.5% GDP decrease	x	x	x	.5%↓	x	x

[1]X = 1983 levels	3.45	1189.3	1417	818	-350	2.75%.

[2]Var = variable production.

15	Optimistic	3.00	3%↑	1%↑	1%↑	5%↑	x
16	Trade increase	x	5%↑	.25%↑	x	5%↑	x
17	Pessimistic	x	5%↓	x	2%↓	2%↓	x
18	Trade decrease	x	5%↓	.25%↓	x	5%↓	x
19	Variable production baseline	x	x	Var	x	x	x
20	Variable production optimistic	3.00	3%↑	Var	1%↑	5%↑	x
21	Variable production pessimistic	x	5%↓	Var	2%↓	2%↓	x
22	Variable production trade decrease	x	5%↓	Var	x	5%↓	x
23	Variable production trade increase	x	5%↑	Var	x	5%↑	x

APPENDIX E. LINEAR MODEL

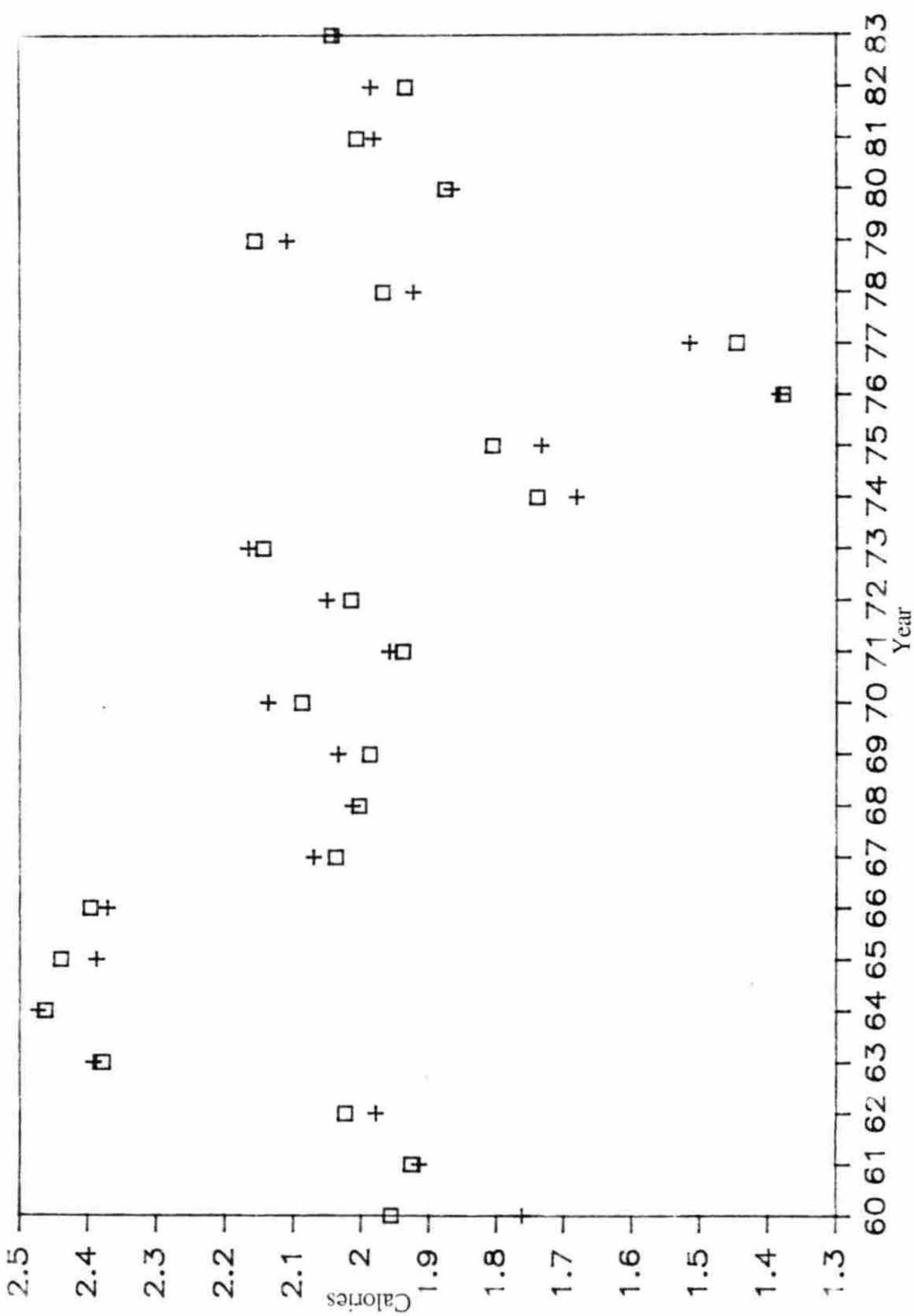
Pindyck and Rubenfeld (1981) suggest using other econometric methods can be used to validate the Logit model. one way is to run a linear regression model with the same data (but with the dependent variable specified as a continuous variable). For this test, the dependent variable was specified as TOTCAL, and the independent variables where PCGDPDEX, CALGDPD, MP, and USFEV. The results obtained indicate the significance of those variables in predicting the amount of food available for consumption. The model statistics are given below, and a plot of actual and predicted values follows (see Fig. E1). An additional features of this model is that it will not predict calorie availability greater than 2085 (95 percent of FAO minimim) when the actual calories available are less than 2085, and vice versa.

Variable	Estimate	t-statistics
PCGDPEX	.276	1.739
CALGDPD	.238	2.493
MP	.977	8.026
VSFEV	-2436.82	-3.09
Intercept	509.72	2.038

R^2 = .9783

D.W. = 1.48

Fig. E1. Linear model. Plot of ancual (◘) and predicted (+) calorie consumption


Calories
Year
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83